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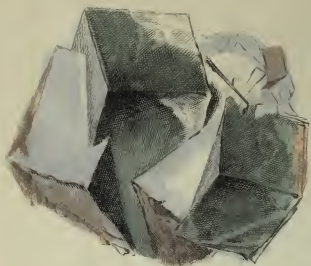
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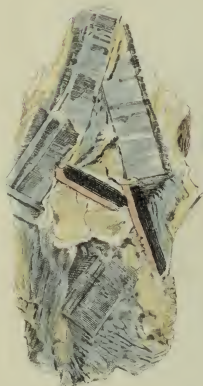
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*Fluor spar.*



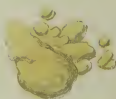
*Beryl.*



*Kyanite.*



*Australian Malachite.*



*Californian Gold.*

*J.W. Lowry, fec.*

RUDIMENTARY TREATISE  
ON  
MINERALOGY.

THIRD EDITION:

TO WHICH IS ADDED,

*A Treatise on Rocks or Mineral Aggregates,*

BY JAMES DANA, A.M.,

OF THE UNITED STATES.

TWO PARTS, COMPLETE IN ONE VOLUME.

With Illustrations.

LONDON:  
JOHN WEALE, 59, HIGH HOLBORN.  
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## ADVERTISEMENT.

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IN the following pages the Student and Amateur in Natural Science are furnished with some information about most of the mineral substances that are met with, either on the surface of the earth, in rocks, or in mines. There are still many others in Nature, besides those herein described; some of which are rare; several have never been analyzed; others only partially examined, and their proper situation hardly established; and the majority of them are unimportant, especially to one little acquainted with the subject.

In accordance with the *natural systems* which prevail in other branches of Natural History, the classification adopted is chemical, and is nearly that of Beudant; a system which recommends itself by its simplicity.

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A third edition of this useful work being called for by the extensive sale of the first and second editions, I have added in this edition Mr. Dana's admirable Treatise on Rocks.

J. W.

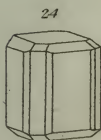
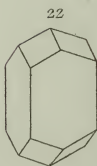
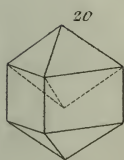
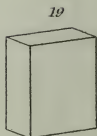
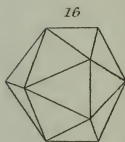
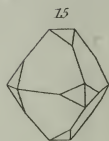
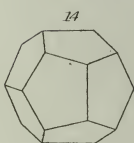
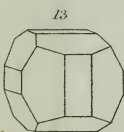
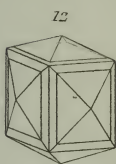
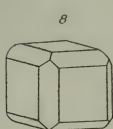
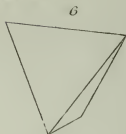
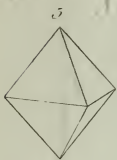
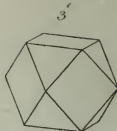
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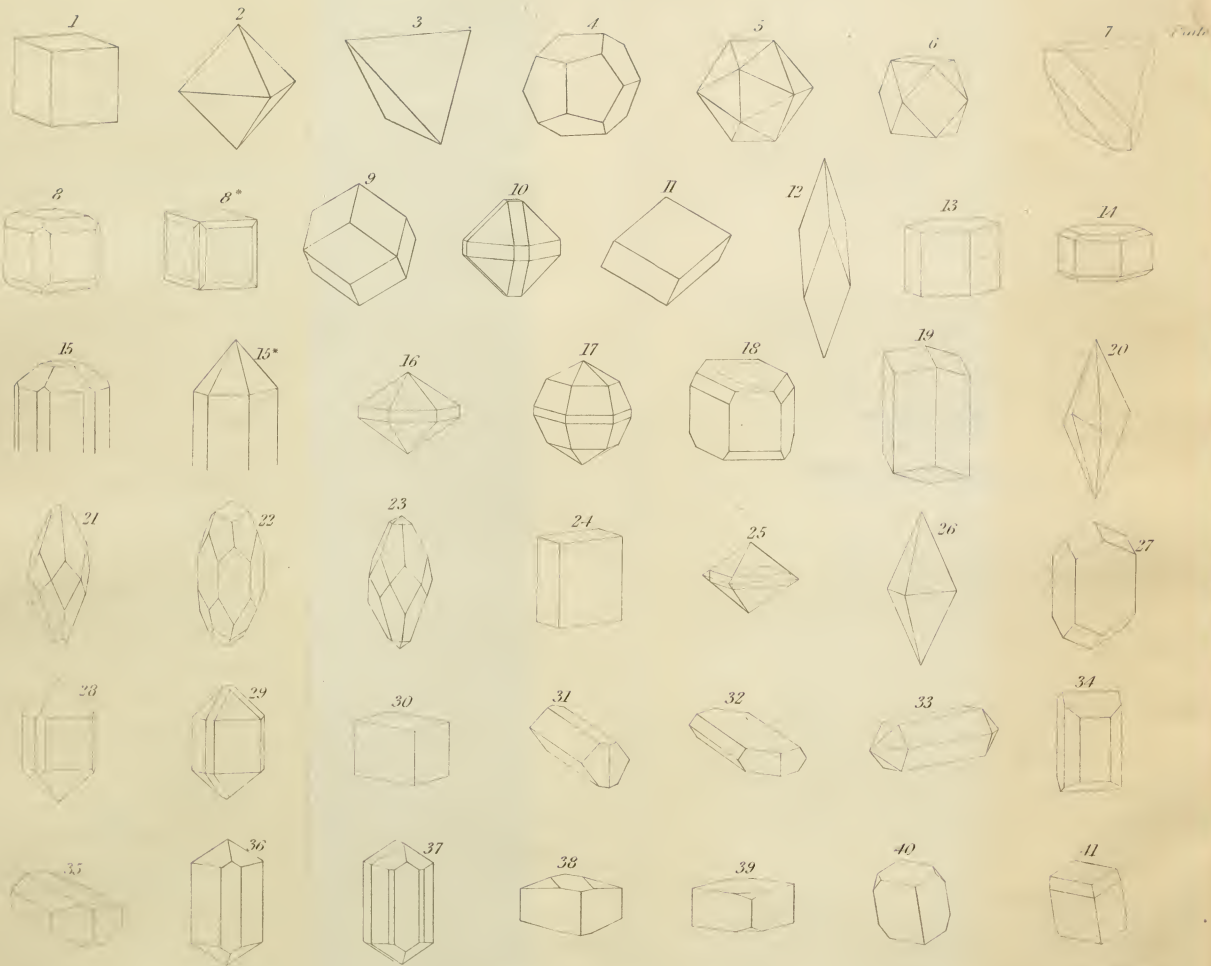


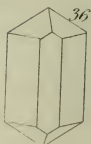
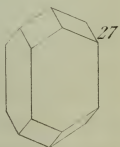
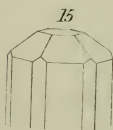
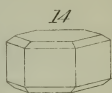
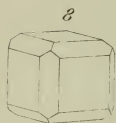
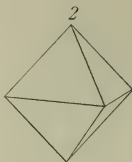
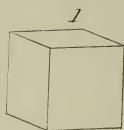
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J.W. Lowry sc.







# MINERALOGY.

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1. NATURAL HISTORY is a science which consists of many branches; one, which treats of animals, is called Zoology; another, Botany, teaches the structure and properties of plants; the third, which makes us acquainted with the inorganic portions of our planet, namely, stones or minerals, is called Mineralogy; and if, at first sight, it should appear less attractive or less useful than the other two branches, a very little consideration will prove that it is of equal importance to mankind, and contributes materially to their comfort, wealth, and luxury. From materials found in the interior of the earth we erect our dwellings, we supply ourselves with fuel, we construct numberless tools and machines, and, finally, we obtain our most brilliant ornaments.

Some knowledge of many of these substances must have been possessed at a very remote period. The most ancient nations of whom we have any record manufactured arms, and ornaments of gold and silver. The Romans, who made great improvements in the arts of civilisation, greatly enlarged this knowledge; bringing to light many substances previously unknown, and employing them for useful or ornamental purposes: they were acquainted with several of the precious stones, and, with the exception of the diamond, succeeded in cutting and engraving on them.

The elder Pliny, a man of enquiring mind and unwearied diligence in the pursuit of knowledge, collected, from every source within his reach, accounts of all the natural productions

that were then known, or of which any description existed in his time; and he added to these his own observation on such as he had actually examined. It is much to be regretted that the latter were not more numerous; for he too often copied, without enquiry, the descriptions he met with; and has transmitted to us a vast number of inaccuracies and absurdities, such as accounts of the magical properties of certain stones, plants, and animals, and charms by which particular diseases might be cured.

As civilisation extended, and the arts of life advanced, a greater number of useful minerals became known: improvements in machinery and practical science led to greater facility in the working of mines, metals were more sought after, new ones were discovered, and new and rich ores of those already known were found to exist, which had formerly been thrown aside as valueless, from ignorance of their nature. Mineralogy now became a subject of importance, and much attention was paid to it: but it still retained somewhat of a vague and unsatisfactory character, from want of knowledge of the principles on which it ought to be based. Chemistry, indeed, lent its aid in the analysis of minerals: but it was before chemistry itself had been raised to the state of an exact science by the wonderful and beautiful law of *definite proportions*,—a law which pervades all chemical combinations, whether natural compounds or the result of operations in our laboratories. This law assists us in ascertaining with *precision* the composition of mineral substances, and consequently in identifying mineral species, and giving them their true place in a scientific classification.

The want of some knowledge of the real nature of stones, which even a slight acquaintance with mineralogy would furnish, has occasioned to many persons, within a comparatively recent period, very ruinous loss; whilst others have rapidly acquired a fortune from profiting, under similar circumstances, by opportunities that had been unseen or totally neglected. It is not above fifty years since a man found in Shropshire a

considerable vein of sulphate of baryta, which, in consequence of its weight, he mistook for white lead ore, and he erected a smelting-house and furnaces for the purpose of reducing it to a metallic state. Another person in the same county, having met with some mica in the form of small silvery scales or spangles, was persuaded that he had found a silver mine, and ruined himself in attempts to obtain the silver.

Among many other unfortunate adventures which have arisen from ignorance of mineralogy, may be mentioned that of a poor man, who was persuaded to lay out a hundred pounds, nearly the whole of some years' economy, in the purchase of a few pieces of white topaz, under the idea that they were diamonds. But independently of the *utility* of this science, any one who studies natural history for his *amusement*, will be richly rewarded by the wonders and the beauties displayed in the mineral kingdom.

§ 2. The bodies which are the objects of study to the mineralogist, comprise the earthy, metallic, saline, and other substances which compose our earth; that is to say, the unorganised part of the creation.

To understand clearly what is meant by the term *unorganised*, let us remember that an animal and a plant are said to be *organised*, because they consist of several different parts, all varying in their form, their position, and their functions, yet all equally necessary to form a perfect animal or a perfect plant; so that to remove any one of them, would be to destroy, or at least to render imperfect, the body to which it belongs. These parts are called *organs*; in animals we find a *stomach* to digest the food they convey to it, and by means of which they are nourished and have life; *nerves* and *muscles* for sensation and motion; in plants we observe a *root* to fix them to the ground, and absorb nourishment from it, and *vessels* for the circulation of the *sap*.

But in a mineral, in its most perfect state, all the parts exactly resemble each other; so that, by breaking it, we diminish it in size without destroying its existence or its com-

pleteness. Take, for example, a flint pebble, or a fragment of limestone from a quarry, and break it: we shall find that each substance is of the same texture and composition throughout. It is true that we may also take up a stone, or break off a piece of rock, which has not this homogeneous structure; as, for instance, a granite paving stone: but granite is an aggregate rock, which consists essentially of three simple minerals, each of which may plainly be distinguished on inspection; and mineralogy teaches us to recognise in it, 1st, quartz, which usually appears in greyish semi-transparent grains, of a somewhat glassy appearance; 2nd, felspar, of a reddish or yellowish white, and opake; 3rd, mica, in small scales which have a shining and somewhat metallic lustre.

The present work is designed to afford such information in mineralogy as may assist any one to ascertain the names and properties of minerals either in studying this branch of science at home, or as a means of increasing the interest he may feel in collecting during his travels.

It is true that the essential difference of minerals consists in their composition; but it is not, therefore, necessary to subject every mineral to chemical analysis in order to know something of its nature. The difference of composition is manifested in difference of form, structure, colour, weight, hardness, transparency, &c.; and an acquaintance with these and some other properties or characters will, in most cases, enable us to recognise a mineral species; and to know of what elementary substances it principally consists. With these, which are called the *external* and *physical characters*, we shall endeavour to make the student acquainted.

But it sometimes happens that we meet with a specimen in which these characters are not clearly marked; or some of them may have a great resemblance to those of another species: in such cases we may derive great assistance from an examination of some of the *chemical characters*, by means of acids and the action of the blowpipe, which have a very different effect on different species.

§ 3. Among the characters of minerals, the most important, because the most constant and obvious, is their *regular* or *crystalline form*.

The regular figures of rock crystal and the diamond, attracted the attention of the ancients, and are mentioned by Pliny : but they were considered, till a much later period, only as curious accidental circumstances. Linnæus was the first who suggested that they must be the result of constant properties, and might be important in the study of minerals : but he appears to have been acquainted with very few, and to have neglected the subject.

Rom de Lisle, a French mineralogist, collected a vast number of crystals of different substances, examined them with care, and, by comparing together those of the same species, found, not only that certain angles were invariable, but that figures the most unlike had a relation to each other ; that they were derived from some fundamental form, altered by the solid angles or edges appearing to be removed, and replaced by one or more planes, sometimes small, sometimes so large as to efface those of the original solid, and to produce another.

§ 4. As an example of this relation, let us compare some of the crystals which are common to Galena (Pl. I.). Fig. 1 is a perfect cube : in fig. 2 the solid angles appear to be removed and to be replaced by small triangular planes : in fig. 3 the triangular planes are increased so as to meet each other : in fig. 4 they are still larger, and intersect each other. The crystal now assumes the appearance of an octahedron of which the solid angles are replaced by small square planes. When the triangular faces increase in size, to the exclusion of the square ones, we have a complete and regular octahedron, fig. 5.

If the *edges* instead of the angles of the cube be replaced by planes inclining equally on the adjoining faces, fig. 8, they will, if increased, produce a dodecahedron with rhombic faces (fig. 9). The same form will be obtained if the planes which replace the edges of the octahedron, as in fig. 10, be enlarged

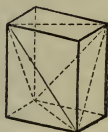


till the original ones disappear. In this figure, the solid angles are of two kinds: six, which coincide with those of the inscribed octahedron, are formed by the meeting of *four acute* plane angles; the remaining eight, which agree with the angles of an inscribed cube, are composed of *three obtuse* plane angles.

This connection between solids of very different form will be better understood if the student will take a cubic crystal of fluorspar, and with a knife, properly placed, and a sharp blow from a hammer, detach from each solid angle a small three-sided pyramid. The faces so produced will always be equilateral, and the solid obtained will be similar to fig. 2 or 3, Pl. I.

If only four alternate angles of the cube be removed (in the direction of the dotted lines No. 1), or, which is the same thing, if four alternate faces of the octahedron be enlarged till the others disappear, he will obtain (fig. 6.) the regular tetrahedron.

No. 1.



The modification represented in fig. 12, Pl. I., a bevelled cube, if carried to its greatest extent, would produce a solid of 24 faces, which is not uncommon in fluorspar: but it often happens that only *half* of the modifying planes occur, and that they are then placed alternately on the similar edges (as in the last example they were placed on the alternate angles): the cube thus modified would be represented by fig. 13, and if the bevelling planes were enlarged till they effaced those of the cube, we should have a pentagonal dodecahedron, fig. 14.

The same planes occur on alternate angles of the octahedron (fig. 15), and when they are increased, the two modifications together produce the icosahedron, fig. 16, a solid of 20 faces.

The angles of the cube are sometimes replaced by three planes, as in fig. 17, which, if enlarged, would finally produce a solid of 24 faces, called a *trapezohedron*, fig. 18, a form often

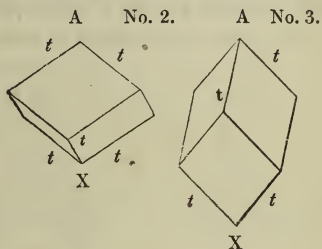


met with in the garnet. It will easily be seen that the same form is derivable from an octahedron.

§ 5. In this manner, the multitude of crystalline forms at present known, and which amount probably to some thousands, may be referred to a very small number of simple figures, each of which is the *base* or *type* of a group. The first of these groups consists of the solids we have enumerated, which may all be referred either to the cube or the octahedron; besides an indefinite number which may be conceived to arise from the replacement of angles and edges by additional planes, and various combinations of those above mentioned.

The simple forms from which those of the second series are derived, are the hexagonal

prism and the rhombohedron. The latter solid is of two kinds; No. 2 represents an obtuse, No. 3 an acute rhombohedron. They must not be confounded with the oblique rhombic prisms; for the faces of a rhombohedron



are always exactly similar and equal: and it is represented in a symmetrical position when the axis, A X, is vertical; and all the modifications to which it is liable take place symmetrically with relation to this line, which passes through the *summits* of the rhombohedron. If the student examine a model of this solid, he will see that these summits differ from the other solid angles, (which are termed *lateral*,) being formed by the meeting of three equal plane angles: in No. 2 these are obtuse, in No. 3 acute. He will also distinguish the *terminal edges*, *t t t*, which meet at the summits, from the *lateral edges* which meet in the lateral angles.

Equilateral six-sided pyramids and triangular dodecahedrons of which the edges are alternately equal twelve-sided prisms, either simple or united with some of these,

and rhombohedrons of various angles, also belong to this group.

The replacement of the *terminal edges* No. 4 produces a rhombohedron more obtuse than the primary one No. 5, and

No. 4.



No. 5.



No. 6.



No. 7.



the replacement of the *lateral edges* gives the regular hexagonal prism No. 6; its bases resulting from the replacement of the summits of the rhombohedron No. 7.

But if the lateral edges be replaced by *two planes* this modi-

No. 8.



No. 9.



No. 10.



fication, if continued so as to destroy the primary faces, would produce a scalene dodecahedron No. 8: that is to say, of which the triangular planes have their sides unequal.

The double six-sided pyramid with *equal faces* No. 9, and another hexagonal prism No. 10, arise from the replacement of the *lateral angles* of the primary solid; and it will be seen that the *lateral faces* of this prism correspond in situation with the *edges* of the one above described.

Among the crystals of calcspar, the student will find all these modifications of the rhombohedron and very many others.

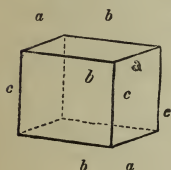
The square prism (fig. 19) is the basis of a very symmetri-

cal group, all the lateral faces being equal, and similarly situated: for it is a general law in crystallization, that whatever secondary planes are found to replace any solid angle or edge of a crystal, every similar angle or edge will be similarly modified. In the cube, therefore, and all the simple solids of that series, every edge and angle undergoes the same alterations.

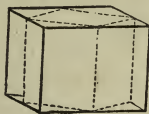
Various octahedrons, both acute and obtuse (figs. 20, 21), prisms with eight, or twelve, or sixteen sides (figs. 23, 24), and rhomboidal dodecahedrons, which, though symmetrical, are not regular (fig. 22), belong to this type (figs. 19 to 24).

The crystals derived from a right prism with a rectangular base, form a series which has less symmetry than these, because only the opposite faces, two and two, are equal; and the longer and shorter edges exhibit separate and sometimes very different modifications: of these, four and four are equal, and in all respects similarly situated, as marked in the diagram.

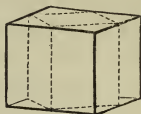
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No. 12.



No. 13.

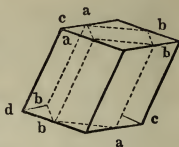


The second and third figures show the relation of the right rhombic prism to this parallelepiped: in the one, by removing the lateral edges of the rectangular prism, by planes parallel to its diagonals, we obtain one with a rhombic base: and in the same manner the rectangular prism may be obtained from the rhombic one. Both are primary forms, and from them are derived octahedrons with a rectangular or a rhombic base.

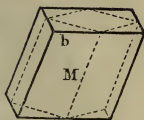
In the same manner, from an *oblique* prism with a rectangular base, we derive a rhombic one; of which the axis and lateral faces will have the same inclination to the base; these are fundamental figures of the fifth series. The symmetry

and equality of the edges and solid angles are indicated by a repetition of the same letters: the secondary forms, which are the consequence of their various modifications, will be noticed in the description of such minerals as have one or other for

No. 14.

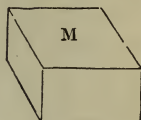


No. 15.



their primary crystal. It should be observed, that if the oblique prism with a rectangular base be placed on one of its lateral faces, it may be considered to be a *right prism*, with a rhomboidal base: by comparing the annexed diagram No. 16 with the former one No. 15, the identity of the two solids will be evident.

No. 16.



The last group has for its basis a parallelepiped which has the least possible symmetry; an oblique prism with an oblique angled parallelogram for its base, No. 17. The only equality both of sides and angles, in this solid, is in those which are diagonally opposite.

No. 17.



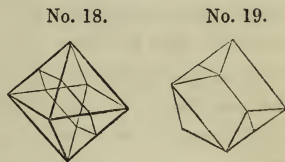
The forms belonging to some of these groups are common to several different substances, as for instance, the cubic series, which includes the crystals of the native metals, of galena, spinel ruby, fluorspar, and several others: in the rhombohedral series we find the crystallizations of calcspar, the beryl, phosphate of lime and of lead, red silver ore, &c.

§ 6. Crystals are found much more commonly in groups than singly, and their modes of arrangement are very various. Cubes are sometimes aggregated so as to form an octahedron, as we see in fluorspar; rhombohedrons are sometimes built up into the form of a triangular dodecahedron, as in calcspar; prismatic crystals are very often united together at one extremity, forming a radiating mass with pointed terminations

on the exterior part: this is the case with several kinds of zeolite, amethyst, and many other substances.

§ 7. But the most singular groups are those called *maeles* or *hemitropes*, because they resemble a crystal which has been cut in two, and of which one part has been turned half round and re-united to the other.

Such a division and re-union, has, of course, never taken place; a macle consists in reality of two crystals, united by a corresponding face of each, but placed inversely with



respect to each other, and which appear to have increased after their union, by a continual addition of particles to each, until the plane of junction is considerably extended. This plane is sometimes parallel to two opposite faces of the primary crystal, as in the example of the regular octahedron: sometimes diagonal, as in the oxyde of tin, felspar, and other minerals.

§ 8. In all these numerous forms, we find in the same species, the same angles or inclinations of planes, however irregular they may appear from the unequal size of the faces. Distorted crystals of quartz are of very common occurrence,—one face of the pyramid is often much enlarged at the expense of the others; yet the inclinations of the corresponding faces in this and the regular hexagonal pyramids will be found to be the same in both.

§ 9. In order to ascertain the measure of these angles, and thus establish the identity of a species, an instrument called a Goniometer\* is employed. There are several kinds, but that invented by Dr. Wollaston is most generally used, being simple in its construction, and easy of application. It consists, No. 20, of a graduated circle A B, placed vertically, the axis being hollow, in order to enclose an interior one

\* From two Greek words, *gonia* an angle, and *metreo* I measure.

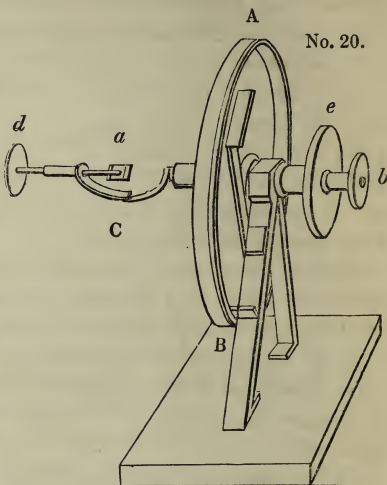


supporting a moveable apparatus C, which is turned by means of the small circle *b*. In order to make use of it, the large circle, which is divided twice into 180 degrees, must be placed at zero (or  $180^\circ$ ), and the crystal attached with a little wax to a small plate *a*, so that the edge may be horizontal, and as nearly as possible in a line with the axis of the circle.

Place the instrument on a firm table before an open window, from which the horizontal lines of some building may be clearly seen, such as the ridge of the roof, the rail of a balcony, &c. ;

let the plane of the circle be also, as nearly as possible, perpendicular to the plane of the building so viewed.

Placing the eye then very near, and somewhat above the crystal, the inner axis is to be gently turned, until the reflection of one of these lines (the higher ones are generally the best for the purpose,) is distinctly seen by reflection, on the upper face of the crystal; and this movement is to be continued until the reflection appears to coincide with some other horizontal line, seen by direct vision; such as the lower edge of the open window, or the edge of the table. If these two lines correspond exactly, the face of the crystal is placed horizontally; if not, its position must be gently altered by means of the jointed apparatus which supports it, or by turning the circle *d*. The same operation is to be repeated with the second face; and if its position requires to be corrected,





the first face must be re-examined, lest its horizontality should have been deranged.

Supposing the crystal to be now perfectly adjusted, and the reflected line on the first face brought to coincide with a lower one, the great circle must be turned by means of *c* (the crystal being turned by the same motion,) until the *same* distant line is reflected in the second face, and brought to correspond with the same lower line.

We shall find the value of the angle sought indicated on the graduated circle, which has turned through the space of the *supplementary angle*; but being graduated in a contrary direction, the true angle is read off.

§ 10. It will generally be found that the faces of small crystals are more perfectly even than those of large ones; they are therefore, in every respect, better adapted for examination by the reflecting goniometer. But even in those which appear the most perfect, a comparison of the angles of several crystals, shows that they sometimes differ *to a very small extent*, in consequence of slight depressions or elevations on their surfaces. But in a great number of substances, their natural structure affords us the means of ascertaining the angles of the primary form with the greatest precision.

This structure, which is inherent in their nature, depending on the arrangement of the minute particles of which they consist, becomes perceptible by the manner in which they divide or split when we break them. A slight blow on a piece of calcspar will separate it into fragments which are either rhombohedrons or parallelopipeds, of which the faces meet at the same angles as the planes of the rhombohedron: this solid is therefore, from its symmetry, considered to be the primary form of its crystals.

If the blow be too slight to shatter the specimen, it will often produce internal fissures, which are distinctly seen, in consequence of the light they reflect, to be plane surfaces parallel to the external ones: these are called *planes of cleavage*; and calcspar is capable of this kind of division in three

directions, with equal facility. Sulphate of baryta, also, has three cleavages, which are parallel to the faces of a right rhombic prism. In this case also, the regular solid obtained by cleavage is considered to be the primary form of the species, though in the latter instance, the same crystals might be derived from (or referred to) a right prism with a rectangular base.

§ 11. It will be evident then, that the observation of crystalline structure, where it exists, is of the greatest importance in mineralogy, not only as showing the relation between forms the most dissimilar, but as affording ready proof of the identity of a species, in circumstances where it would otherwise be extremely difficult to distinguish it; when, for instance, it is disseminated in minute portions through some other mineral: felspar, diallage, and some other substances frequently occur in such a situation.

Some minerals, however, may be cleaved with much greater ease in one or in two directions than in the third. Some yield to cleavage in one direction only, as in the case of mica and selenite.

§ 12. Besides the regular and perfect crystallizations of minerals, of which we have given an outline, the aggregation of crystals more or less perfect gives rise to numerous configurations, some of which are peculiar to certain species. In some, the crystals are grouped into spheroidal masses, the edges or points of the crystals appearing on the exterior of the mass, as in blue carbonate of copper, iron pyrites, &c.

The slender prisms in which many substances crystallize are often compressed together lengthwise, and form cylindroidal or bacillar groups; the crystals, even on the exterior, being always deformed and their edges rounded.

The branched and leafy forms and moss-like aggregations, so frequently met with in some of the native metals, consist of more or less perfect crystals. When the crystals are *very* minute and the branches of a more even thickness, they present the form of coral.

§ 13. The stalactites which so often occur in caverns, irregularly conical or cylindrical in their form, or incrusting their walls, are produced by the deposition of minute particles, generally calcareous, from water which percolates through their roof or sides. When a small quantity of moisture arrives at the inner surface of the roof, before a drop is formed sufficiently large to fall by its own weight, a portion of it evaporates, and a ring-shaped film of solid matter is left adhering to the rock. Every succeeding drop increases the thickness of this film, until at length a slender tube is formed, which is constantly increased in thickness as well as in length. In general the interior is quickly filled up, and becomes perfectly solid: but sometimes the stalactites are hollow throughout a great part of their length. When the water drops more rapidly, a portion of it falls on the floor of the cave, depositing there solid particles, which accumulate and produce masses resembling moss, fungi, and cauliflowers, which are sometimes called stalagmites.

§ 14. Minerals, also, which do not crystallize, often assume definite forms externally, which are characteristic and deserving of attention. In some the surface consists of portions of spheres of different dimensions: when these are small, somewhat resembling a bunch of grapes closely pressed together, the mass is termed *botryoidal*:\* when the globular surfaces are of larger dimensions, it is said to be *mamillated*:† calcedony and malachite are good examples of these forms: and the nodules of iron pyrites, which exhibit a similar surface on a smaller scale, are called *reniform*.‡

§ 15. We have already remarked that in many substances which crystallize, their regular or laminated structure becomes visible on breaking them: but minerals which do not yield to cleavage in any direction, or with difficulty and uncertainty, break into indeterminate fragments: their form varying with the texture of the mineral. In those which are crystalline

\* From the Greek word *botrus*, a cluster of grapes.

† Lat. *mamma*, the breast.

‡ Lat. *ren*, a kidney.

and may be termed vitreous, as Quartz and Beryl, the fracture of the broken part is said to be *conchoidal*, a form which is illustrated in the fragments of glass; a still better example of the conchoidal fracture is to be found in breaking a large flint pebble; the texture of flint is *compact* and *even*, and all minerals possessing the same kind of structure or texture, break in a similar manner.

In others, which are less hard and compact, the fracture will be *uneven* or *earthy*. The native metals, if they do not afford cleavages, have a *hackly* fracture, which may be observed on breaking a piece of thick wire, or plate of metal.

The fibrous structure common to many species, arising from an aggregation of delicate prisms, sometimes parallel, sometimes divergent or radiated, is also evident in the appearance of the fracture. Hence the fresh fracture of a mineral makes us somewhat acquainted with its structure, and should always be remarked.

§ 16. Among the optical characters of minerals, some are not only very remarkable, but, like their crystalline forms, they belong to the disposition of their particles, and are equally constant in the same species. Of such kind are the phenomena of refraction: other properties relating to light, such as the colours and transparency of minerals, are in some species characteristic; but in others they are frequently varied by accidental causes.

The property of *double refraction* possessed by many substances, is particularly evident in the transparent varieties of calcspar, which have obtained from this circumstance the name of *doubly refracting spar*. If a line traced on paper be viewed through a fragment of this mineral, *two lines* will appear; and on turning the calcspar round, as it lies on it, both images will move until they coincide; and on turning it still farther, one will seem to pass over the other. This is because one portion of the light is refracted in the ordinary manner, as we see in glass and water; the other portion, called the *extraordinary ray*, is refracted in a different manner:

and it is found that excepting those substances whose crystals belong to the cubic system, and such as do not crystallize, all minerals have, in a greater or less degree, the same property.

But there is one direction in which a line (or any other object) may be viewed through calcspar, without appearing double; this is in the direction of the axis of the rhombohedron. If the two summits of a rhombohedron, or the bases of an hexagonal prism be polished, on placing it over a dot, and the eye immediately above it, we shall see but one image of it.

In the crystals also, which are referable to a square prism, no double refraction is perceptible in the direction of their axis: in both cases it is called the *axis of double refraction*.

In crystals where this kind of symmetry does not exist, as when they are derived from prisms that are oblique, or have not a square base, there are *two* axes of double refraction, or two directions in which only a single image will be perceived.

The property of double refraction may therefore be valuable in assisting us to distinguish minerals, which at first sight appear to resemble each other, if, being cut and polished, or in irregular fragments, we have no indication of their external form. A fragment of red topaz, for instance, will refract doubly: one of spinel ruby, the crystals being octahedral, will not.

§ 17. But as the amount of double refraction is, in most substances, very small compared with that of calcspar, it is seldom possible to discover, by merely looking through them at a line or dot, whether they really possess this property; besides the difficulty there may be of having transparent fragments of sufficient size to be cut in different directions. A simple experiment, however, with polarized light, will determine the point.

Light may be polarized by several different methods; as, by reflection at a certain angle, from a polished surface; by transmission through plates of tourmaline, &c. For the



mineralogist, two thin plates of this substance, cut parallel to the axis of the crystal, afford the most convenient apparatus. They are to be fixed, each in the aperture of a short tube of wood or brass, of such dimensions that one shall be capable of turning within the other. On looking through the two plates, placed with their axes *parallel*, we shall see, as in any similar case, the brown or green colour of the tourmaline; but if one of them be turned, so that its axis shall be at *right angles* to that of the other (their planes being still parallel), the light will be wholly, or almost entirely, intercepted. On introducing between them a fragment or plate of the mineral under investigation, if it do not possess the property of double refraction, no change will take place: but if it refract doubly, light will be visible, and in a very singular manner: a number of concentric coloured rings will be seen, intersected by a black cross. On turning either plate of tourmaline one quadrant of the circle, the appearance will still be the same; as also when it has described half or three quarters of a revolution: but at all the four intermediate points, a white cross will take the place of the black one, and the coloured rings will occupy the dark spaces that intervened between those of the former set, figs. 1 and 2.

If the mineral have but one axis of double refraction, and the plate be cut perpendicularly to it, the rings will be circu-

No. 21.



No. 22.



No. 23.



No. 24.



lar; if obliquely, they will be elliptic.

But if the crystal belong to any of those series which indicate *two* axes of double refraction, there will be two adjoining

systems of coloured rings, traversed by a black cross, No. 23; and on turning one of the plates of tourmaline so as to produce the complementary system of rings, they will have the appearance represented in No. 24. Many other phenomena presented by minerals, when viewed with polarized light, are extremely curious and beautiful, but they are far too numerous to be detailed here.

§ 18. The character of transparency exists in various degrees in minerals: some are perfectly *transparent* (and when colourless also, are said to be *limpid*); others, which allow objects to be indistinctly seen through them, are *semi-transparent*: when they transmit only a little light, they are said to be *translucent*. Some are translucent only on the thin edges of fragments; others are quite opaque. But it should be observed whether opacity is really a character of the species, or whether it is caused by the intermixture of some foreign matter. Opacity is sometimes also the consequence of decomposition, loss of water, &c.

§ 19. With regard to the brilliancy of minerals, there are several kinds of lustre which are very distinct from each other: for instance, some have a *metallic* lustre, others a *vitreous* or *glassy* lustre: others, again, either from the nature of their texture or structure, exhibit an *adamantine*, *oily*, *resinous*, *waxy*, *pearly*, or *silky* lustre.\* Many substances, being of an earthy texture, are without lustre, or quite *dull*: in others, according to their degree of compactness, we find several degrees and varieties of lustre in various parts of the same mass.

There is also a kind of lustre peculiar to some minerals, denominated *semi-metallic*; it is very commonly found in mica, as well as in some metallic ores.

§ 20. The *degrees* of lustre should also be remarked; the highest degree, *splendent*, is applied almost exclusively to the

\* The *pearly* lustre which is often to be observed on the bases of prismatic crystals, appears to be the result of a laminated structure; and the *silky* lustre, of a fibrous structure.

diamond and white carbonate of lead, which from their very high refractive power have a greater brilliancy than any other substance.

Many crystals are *brilliant*; others are *shining*, *glistening*, or *glimmering*: and these terms apply also to the appearance of the fracture, which should always be observed when recently made, and before it loses the form and lustre that are peculiar to it.

Some minerals which are soft, and have little or no lustre, become shining when scratched by a sharp point.

§ 21. The colours of minerals are either essential to them, as in the sulphurets, oxydes, and acidiferous compounds of most metals, and in those species of which they are essential constituents; or they are the effect of a casual intermixture of these substances in species which, when pure, are naturally colourless. Of the latter sort are the colours of felspar, calc-spar, rock salt, marble, and jasper, in which the various tints of red and yellow are generally due to the oxyde and hydrous-oxyde of iron. Other minerals derive a brilliant green colour, some from carbonate of copper, others from the oxyde of nickel or of chrome. In species of which the colour is a permanent character, its intensity is often so far varied by a difference of texture or a confused crystallization, that red, brown, and green substances appear, in a mass, to be black; but on being pulverised, their true colour will be seen; it is therefore advisable, in describing a mineral, to state what its colour is when reduced to powder.

The intermixtures of colouring matter, which are merely mechanical, render a mineral more or less opaque: thus, the red and yellow jasper, already mentioned, are calcedony (which when pure is highly translucent, or even semi-transparent), coloured by minute particles of oxyde of iron, which are themselves opaque. But colours, which, though they may not be essential to a species, are the result of *chemical combination*, do not impair its transparency: such is the violet tint of amethyst, which is derived from a minute portion of the oxyde of man-



ganese combined with the quartz; and the green of the emerald, which is owing to the oxyde of chrome.

In consequence of the variable quantity of colouring matter, whether chemically combined or otherwise, many substances present various tints and shades of colour; so that we particularise them as *blood-red*, *flesh-red*, *chestnut-brown*, *lemon-yellow*, *sky-blue*, &c.

Accidental colours, being unequally distributed, often produce parallel bands, either straight or curved, and clouded forms, as in agates: sometimes the colour takes the form of leaves and moss, or runs through the mass in veins, as in marble.

§ 22. There are still other colours, which are neither essential to minerals, nor yet produced by intermixture. Some, as the sulphuret of antimony, exhibit a brilliant superficial tarnish, in which the prismatic colours are regularly arranged. In transparent substances, prismatic colours are perceived in the interior, and arise from minute cracks or fissures containing films or particles of air: these are often moveable by a slight pressure.

§ 23. A very curious peculiarity of colour called *polychroism*\* is connected with the phenomenon of double refraction. Some minerals, placed between the eye and the light, transmit different colours in different directions: tourmalines, viewed parallel to their axis, are generally opaque; perpendicularly to it, they appear to be green, red, brown, &c. This difference is not observable in *all* doubly refracting substances; but in some which have two axes of double refraction, three different tints have been observed. Minerals crystallizing in the cubic system never transmit more than one colour, if their composition and texture be homogeneous throughout.

§ 24. In some minerals, a peculiar light is produced either by friction or by heating them, which is called *phosphorescence*. On rubbing together two fragments or pebbles of quartz, a faint greenish light will be perceived: the same effect results

\* From two Greek words—*polus*, many, and *chroa*, colour.

from certain marbles. Other substances, when placed on a heated shovel, emit a brilliant phosphorescence, which in some is green; in others, pale violet. The best mode of conducting this experiment, if the specimen is powdered, or in small fragments, is to strew it on a shovel heated nearly to redness: but if it be an inch or two in length, it is better to heat it slowly, and not beyond the necessary degree; by which means the operation may be frequently repeated without injuring it.

§ 25. The hardness of minerals is a character very useful in distinguishing them: but it is necessary to ascertain it with some precision, by comparing it with that of others. In order to facilitate this comparison, a scale of hardness has been arranged, which obviates the use of the indefinite terms, *hard, very hard, rather soft, &c.*, and it is almost equally vague to say that a mineral is harder or softer than some others, unless these standards of comparison be very limited in number. The scale of hardness invented by Mohs, and which is very generally adopted, is subjoined, and may be referred to when this character is described, which is now very usual, by a numeral.

1. Talc—laminated variety
2. Rocksalt (or uncrystallized Gypsum)
3. Calcspars—transparent
4. Fluorspar—crystalline
5. Apatite—transparent
6. Felspar—white, crystalline
7. Quartz—transparent
8. Topaz—transparent
9. Sapphire—cleavable
10. Diamond.\*

\* The interval between Nos. 2 and 3, and between 5 and 6, being rather greater than the others, some mineralogists have thought it advisable to introduce between the former, Foliated Mica, numbering it 2·5 (two and a half); and between the latter, Scapolite, 5·5; in order not to alter the original numeration of the scale.

It must be remembered that hardness signifies, in mineralogy, the resistance which a mineral offers when we attempt to cut or scratch it; and is very different from its *tenacity*, by which we understand its power of resisting a blow. The diamond and the sapphire, the former the hardest substance in nature, and the latter capable of cutting everything except the diamond, are so brittle that they may easily be shattered by the blow of a hammer; while others, which are very soft, that is to say, easily cut or scratched, offer great resistance to a blow.

§ 26. The degree of tenacity of minerals results from their *elasticity*, and is a character depending on their structure. In some, which are compact, it is evident from their rebounding when thrown against a hard surface; in others, which are laminated, from the ease with which the laminæ, after being bent, return to their former position: several minerals also are *flexible* without being elastic; this is the case with several fibrous substances.

§ 27. The comparative *weight* or *specific gravity* of minerals is a highly important character, and will often serve to identify species. The difference of weight of many substances is so great, that we may frequently recognise them immediately by this means: jewellers will thus generally distinguish a sapphire or topaz from an amethyst or rock-crystal, or from coloured glass, notwithstanding a similarity of colour and form. It is therefore desirable to ascertain the specific gravity of minerals with precision.

In order to do so, we must have a standard of comparison which may be termed *unity*. For this purpose we make use of distilled water, at the temperature of about sixty degrees. When, therefore, the specific gravity of gold is said to be 19; of lead, 11; and of topaz, 3·5; it is meant that gold is nineteen times, lead eleven times, and topaz three and a half times as heavy as water.

The method of determining the specific gravity of any solid body is very simple: it is *first* to be weighed exactly, in a

delicate balance; *secondly*, it is to be immersed in water, and again carefully weighed; *thirdly*, the second weight, which is always less than the former, is to be subtracted from it; *fourthly*, the first or absolute weight is to be divided by the difference of the two: the result will be the specific gravity of the specimen under examination. For, the weight lost by the immersion in water, is the weight of a quantity of water, equal in bulk to that of the solid: we therefore make a comparison between a certain bulk of solid matter and an equal volume of water.\*

Thus, a crystal of topaz weighing 100 grains weighs, when immersed in water, only 71.43 grains; and if we divide 100 by 28.57, which is the difference of the two weights, the result will be 3.5, which is the specific gravity of topaz.

In taking the specific gravity of a mineral, it is scarcely necessary to remind the student that it should be most carefully separated from every foreign substance: but even when specimens are selected with the greatest regard to purity, it will still be found that the results of different experiments vary a little. This appears to arise from a difference in their compacity, or mode of aggregation of their particles. In several species, of which a number of specific gravities were taken by M. Beudant, he found uniformly, that small well-formed crystals gave the highest numbers. For instance, small crystals of calcspar were 2.7223 to 2.7234; while portions of a large dodecahedral crystal gave a specific gravity of 2.7068, and a piece of stalactite, only 2.704. It is desirable, on this account, to state, in the description of a species, its highest and lowest specific gravity.

§ 28. The property of *taste* is confined to the soluble minerals, of which some are *astringent*, as the sulphate of iron; a few, *alkaline*, as carbonate of soda; others, bitter,

\* A scale made of open wire-work is preferable for immersion in water, as it offers less resistance to movement in the liquid. In all cases it should be accurately balanced *when in the water*, against the other scale.

as Epsom salt; or *sour*, as the sulphuric acid which occurs among recent volcanic products: a few, as sal ammoniac, are pungent.

§ 29. There are very few minerals which exhale any *odour*, unless by the application of heat or moisture. The bituminous odour is generally perceptible in the varieties of bitumen, and the inflammable substances which contain it; and this becomes stronger when they are heated. The smell of sulphur, which is known to most persons, is immediately perceived in its compounds when they are exposed to heat; and by the same means the odour of arsenic becomes evident: it has a great resemblance to that of garlic. Friction is in many cases sufficient to produce this effect, as in certain bituminous limestones.

On the other hand, many substances when breathed on, or otherwise exposed to a slight degree of moisture, give off an odour which, from being strongly perceptible in all kinds of clay, is called the argillaceous odour.

§ 30. All minerals are more or less susceptible of becoming *electric*, either by *friction*, by *pressure*, or by *heat*; in some, this property may be excited by all these methods. A topaz, a tourmaline, and a number of other minerals, when rubbed on a piece of woollen cloth, will, like a stick of sealing-wax or glass rod (so excited,) attract small light bits of cotton or thin paper. But the metals, and those ores which approach to a metallic state, being conductors of electricity, this result cannot be obtained unless they are previously isolated, by placing them on a support of glass, or some other non-conducting substance. A very small piece of gilt paper attached by a silk thread to a bent glass rod, forms a simple apparatus which will exhibit the electricity a mineral has thus acquired: on approaching it to the gilt paper it will immediately attract it. The specimen, also, should be





suspended by a silk thread, or held in a pair of pincers\* having a glass handle.

The substances which become electric by heat, such as tourmaline and topaz, usually exhibit *electric poles*: that is to say, one end of the crystal becomes positively, the other negatively, electric. This may be ascertained by previously communicating to the gilt paper either kind of electricity. For instance, when the crystal is heated, let the gilt paper be touched by a stick of sealing-wax that has been well rubbed: if the crystal, on approaching the apparatus, repels the paper, that end is also *negatively electric*, and it will be found that the other end attracts it, and is therefore *positively electric*. The crystals which acquire electric poles by heat, have another peculiarity: namely, that their opposite extremities are differently modified: tourmalines are sometimes terminated at one end by three, at the other by six or nine planes. This is yet more striking in the substances whose crystals are cubes modified on the alternate solid angles.

However curious we may consider the electric phenomena of minerals, they appear to be manifested with too much uncertainty to form a distinguishing character. Different crystals of the same substance will acquire, some negative, others positive electricity, according as they are transparent or otherwise; in general, transparent crystals with bright polished faces become positively electric; and such as are not limpid, or have a rough exterior, become negatively electric.

§ 31. The only mineral which is capable of becoming a magnet or loadstone, is the magnetic oxyde of iron: this mineral alone exhibits the magnetic poles; but many iron ores, and even many other substances which contain a large proportion of iron, not too highly oxydised, will attract the magnetic needle perceptibly. The metals *cobalt* and *nickel* likewise possess this property, but less powerfully.

\* The latter plan is objectionable if we wish to ascertain whether the substance is capable of becoming electric by simple exposure to heat, because many which are not so become electric by pressure.

§ 32. Before we speak of the characters which minerals offer when chemically examined, it will be proper to say a little about the various elementary substances of which they consist. We are acquainted with about 500 mineral species: some of these are *simple* or *elementary substances*: that is, our chemical knowledge has not yet enabled us to decompose or separate them into different elements. Such are the *diamond*, which is carbon in its purest state, and the metals, as *gold*, *copper*, *antimony*, &c.; but the greater number of these elementary bodies exist only in combination with these, or with each other.

Many substances which might, at first sight, be thought to be simple ones, are in reality compounds. Water, for instance, consists of two kinds of gas, *oxygen* and *hydrogen*, chemically combined. In the atmosphere, oxygen exists with *nitrogen* gas, in the proportion of 1 to 4. Oxygen, although it is never found alone in nature, exists in so many substances, forming oxydes and acids, that it is one of the most abundant mineral elements. In the earths, lime, flint (or silica), clay (or alumina), and magnesia, it is combined respectively with the metals, *calcium*, *silicium*, *aluminium*, and *magnesium*, which are called their *bases*. It exists also united with iron, copper, tin, lead, and some other metals, in their ores: the above-named combinations are called *oxydes*. With *sulphur*, oxygen produces *sulphuric acid*; with nitrogen, *nitric acid*; with carbon, *carbonic acid* or fixed air. These acids, again, are combined with the earths, alkalies, and other oxydised metals, forming *sulphates*, *nitrates*, and *carbonates*. Some of the oxydised metals too, as *arsenic* and *chrome*, play the part of acids, and mineralise other metals and earths; therefore, we have *chrome of lead*, *arseniate of iron*, *of lime*, &c.: and, among the earths, it is found that silica is the most active or mineralizing agent; producing *silicates* of the earths, alkalies, and metals.

Sulphur, not acidified, is found combined with several of the metals, as iron, silver, copper, &c.: these combinations



are termed *sulphurets*; two or more are often combined in the same species. In like manner, the compounds of arsenic are called *arseniurets*, of tellurium *tellururets*, &c.

§ 33. Some metals, as iron and manganese, combine with different proportions of oxygen, and these combinations, which are always very different in their properties and characters, are distinguished by the terms *protoxyde* and *peroxyde*, the latter always implying a larger quantity of oxygen than the former: in like manner, some of the earths, as silica and alumina, are peroxydes; while others, as lime and magnesia, are protoxydes. It is important to remember this distinction, because a curious property called *isomorphism*\* is connected with it. Isomorphism signifies similarity of form: and it is found that there are in nature several elements which have so close a resemblance in the form of their molecules or particles, and in their crystalline tendencies, that in numberless minerals they replace each other, without sensibly affecting the crystallization of the compound; or they produce only a slight variation in some of the angles. Thus, in the different kinds of garnets, we find in some more alumina, in others more peroxyde of iron, without any change of form: and in the different varieties of augite and hornblende, we find lime and magnesia replaced, wholly or in part, by the protoxydes of iron and manganese; their crystallization remaining the same. These elements are therefore said to be *isomorphous*: and besides those just mentioned, the same similarity exists between the protoxyde of lead and the earths baryta and strontia; between arsenic and phosphoric acid and some few other substances.

§ 34. The principal distinction to be made, then, between the constituents of minerals, is this: *a certain number of them are the active elements which mineralise the others.*† The most

\* *Isos*, Gr., similar, and *morphe* form.

† To explain the classification into electro-negative and electro-positive substances of the elements of the mineral kingdom, would be encroaching too much on the province of Chemistry; or, at least, would be incompatible with a work of so limited a nature as the present.

simple compounds (consisting of only two elements) are called *binary*, and in those which occur in nature it is found that *one* of the constituents must always be one of the twelve following substances :

|          |           |
|----------|-----------|
| Oxygen   | Antimony  |
| Sulphur  | Selenium  |
| Arsenic  | Tellurium |
| Chlorine | Mercury   |
| Carbon   | Gold      |
| Fluorine | Osmium    |

§ 35. But the greater number of the fifty-nine elementary substances known to us, form but a small portion of the earth, as far as we are acquainted with it. The granite and trap rocks, the limestone, slate, chalk, sand, and clay strata, which we meet with all over the globe, consist principally of the earths above named, the alkalis potash and soda, iron, carbonic acid, and chlorine. Water, also, enters largely into the composition of many substances as an essential component : this will not appear extraordinary, if we call to mind the familiar experiment of casting with plaster of paris.

Of the metals, some, as silver, copper, tin, lead, although they are abundant in comparison with tellurium, cerium, and others, occur, with the exception of iron (which enters as a necessary constituent into many of the so-called earthy minerals), only in very thin beds called *veins*, which traverse some of the siliceous and calcareous rocks ; while many have been found only in a few distant localities, and are unknown, except to mineralogists.

§ 36. With regard to the *chemical examination* of minerals, there are two modes of operation, called the *moist* and the *dry* : in the former, they are dissolved, either in water, or, if that is not possible, in some acid ; in the latter, they are exposed to great heat by means of a *blowpipe*. For the mineralogist this mode of operation is by far the most convenient ; both because the results are quickly obtained, and because very little apparatus is necessary : he requires, for his furnace, only a lamp or

candle ; some strips of platinum foil, and a pair of pincers with tips of the same metal, for supporting the specimens to be assayed ; or, in some cases, a piece of well-burnt and solid charcoal ; and a few small bottles containing fluxes.

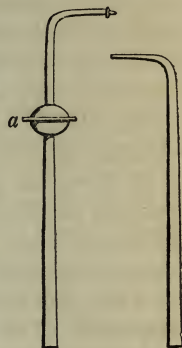
§ 37. The blowpipe, in its simplest form, is a bent tube, nine or ten inches long ; at one extremity tapering to a fine point. It is used to direct and concentrate a flame, by supplying to it a constant stream of air in one direction ; the small end being placed just within the flame, and the air being furnished by the operator *a* blowing through it.

Some difficulty may be experienced, at first, in producing an equal and uninterrupted stream of air and a steady flame : it can only be effected by supplying the air, not immediately from the lungs, but from the mouth, *as from a reservoir*, which must not be allowed to become exhausted ; otherwise, the experiment will be incessantly impeded by the necessary act of respiration.

Some blowpipes have a cylindrical or globular cavity, in which the moisture of the breath is condensed and retained ;\* it might otherwise be carried by the draught into the flame, and would interfere with the experiment.

A silver tube is the best, as not liable to corrosion ; brass communicates an unpleasant smell to the fingers ; but a cheaper instrument may be made of tinned iron, the cavity being square and placed at the bend. In all cases, however, the tip should be of platinum and removable, that it may be cleansed if necessary, in acid, or by heating it to redness.

A small lamp, fed either with oil or melted tallow, will furnish a good flame for the exercise of the blowpipe ; but a candle with a large wick may be used, and, in travelling, is perhaps the most convenient.



\* This cavity is made in two parts and unscrews at *a*.

When the student can produce a steady flame with this instrument, he will find that it now consists of a cone of yellow light, inclosing a blue one. The heat is most intense at the extremity of the blue flame: this is called the *reducing flame*, because it de-oxydises, wholly or in part, the substances that are exposed to it, and it is capable of melting a great number that are not fusible in the outer one. The latter is called the *oxydising flame*, because, as it does not entirely prevent the contact of the air, it permits the subject of experiment to become oxydised.

In the inner flame, some of the metallic oxydes are reduced to the metallic state; and their reduction is assisted by placing them on a piece of charcoal as a support, because it absorbs the oxygen from them when heated. For this purpose, a small hollow may be scraped in the charcoal, and the mineral (previously crushed or powdered) fixed in it with a little wax or tallow, which will prevent it from being displaced on exposure to the draught of air, and will quickly burn away.

A quantity, varying from the size of a mustard seed to that of a peppercorn, is ample for most experiments. Sulphurets, when heated, give off the odour of sulphur, and after some time they are generally reduced to the metallic state. When arsenic is combined with them, the smell of garlic will be perceived: and the few which contain *selenium*, afford a pungent odour like that of horseradish.

§ 38. Some minerals, both earthy and metallic, are fusible by the blowpipe without addition: but many others cannot be melted unless mixed with some alkaline or saline substance, with which they fuse into a glass, more or less transparent, or a kind of enamel: these salts are called *fluxes*: carbonate of soda, borax, and salt of phosphorus, are most commonly used, and they may generally be placed with the subject under examination on a slip of platinum foil. In some cases, the glass produced by fusion is colourless, containing small globules of the reduced metal; in others, it receives from the metal a colour which is peculiar to it: thus, the ores of cobalt

melted with borax (or common glass,) will always produce a fine clear blue colour: those of manganese, a rich purple like that of the amethyst. It must be remarked, however, that the same metallic oxyde will produce different colours with different fluxes, or in the two flames; and therefore, if the result of one experiment should not be satisfactory, it may often be verified by a second. The annexed table, showing the results obtained by subjecting several oxydes to the action of the blowpipe, with different fluxes, will be found useful for reference.

When a mineral is heated in a closed glass tube, by directing the flame against and beneath it, if it contain water, it will be volatilized, and condensed on the upper surface. If *fluorine* be one of the components, the glass may be corroded by it: but this gas is not always disengaged without fusion with salt of phosphorus.

§ 39. As it is not possible in this introduction to detail most of the experiments for examining minerals by *solution*, we will observe, First, that effervescence on the application of an acid generally indicates *a carbonate*: in all carbonates of lime the effervescence is very brisk, but in some other species it is scarcely perceptible without the assistance of heat. Secondly, that some minerals that do not effervesce, when dissolved in acids, are converted into a *gelatinous* substance; this is the case particularly with some siliceous minerals that contain a portion of alkali: heat is often necessary to accomplish this change, and the acid employed should be strong; but to produce effervescence, the acid should be diluted with water.



|               | FUSED WITH BORAX.                       |   | FUSED WITH SALT OF PHOSPHORUS.         |                                     |
|---------------|---|---|--|-------------------------------------|
|               | OXYDATING FLAME.                        | REDUCING FLAME.   | OXYDATING FLAME.                       | REDUCING FLAME.                     |
| OXYDES OF     |   |   |  |                                     |
| Tellurium . . | colourless . . . .                      | grey and opaque; containing minute globules of metal          | colourless . . . .                     | grey and opaque                     |
| Titanium . .  | colourless, or opaque white             | yellow, amethyst, or blue, according to the quantity of oxyde | colourless . . . .                     | yellow; on cooling, a bright violet |
| Bismuth . .   | colourless . . . .                      | reduced—glass imperfectly transparent                         | yellowish brown, colourless on cooling | grey and opaque when cold           |
| Chrome . .    | emerald gr.—brightest cold              | brownish yellow, hot; colourless, cold                        | deep green . . . .                     | pale green                          |
| Copper . .    | bright green . . . .                    | colourless, hot; opaque and deep red when cold                | green . . . . .                        | dark red when cold                  |
| Uranium . .   | dull yellow . . . .                     | dull dark green, approaching black                            | straw yellow, cold .                   | green, most intense when cold       |
| Lead . .      | colourless, cold . .                    | partly reduced . . . . .                                      | colourless . . . . .                   | colourless                          |
| Cerium . .    | orange or red, hot; yellowish, cold     | colourless . . . . .  | red, hot; colourless, cold             | colourless                          |
| Iron . .      | red, hot; yellowish or colourless, cold | bottle green or bluish green . .                              | same as with borax                     | borax                               |
| Manganese . . | amethyst . . . . .                      | colourless if cooled quickly . .                              | amethyst . . . . .                     | colourless                          |
| Cobalt . .    | blue . . . . .                          | blue . . . . .  | blue . . . . .                         | blue                                |

## SECTION II.

MINERALS—and in the arrangement of the unorganised portion of the globe may be included water, the air, and other natural gases—are naturally divisible into three classes, based on the *mineralising* (or electro-negative) principle they contain. Each of these mineralising elements is the base or type of a family; the families are divided into genera, each containing one or more species. The substances which are comprised in the first class have for their type elements which are capable of forming *permanent gaseous combinations* with oxygen, or with hydrogen, or with fluorine: they have, therefore, received the name of *gazolytes*. These substances are silicium, boron, carbon, hydrogen, nitrogen, sulphur, chlorine, bromine, fluorine, selenium, tellurium, phosphorus, and arsenic.

In the second class, the mineralising substances are characterised by forming *colourless solutions* in acids, and may, therefore, be called *leucolytes*.\* The bases of the families in this class are antimony, tin, bismuth, mercury, silver, lead, alumina, magnesia.

The third class unites minerals in which the bases of the families produce *coloured solutions* in acids, whence they have been named *chroïcolytes*:† these substances are manganese, iron, cobalt, copper, uranium, palladium, platinum, gold, chrome, molybdenum, tungsten, titanium, tantalum.

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FAMILY I.—Silicides.

Genus I. Silica.

— II. Silicates.

\* From two Greek words, *leucos* white, and *lutos* soluble.

† *Chroïkos* coloured, and *lutos*.



The genus *silica* contains but two species—

1. Quartz.

2. Opal.

Quartz presents very numerous varieties of form, colour, transparency, &c. : but it may be distinguished into two principal kinds, *vitreous* and *calcedonic*.

VITREOUS QUARTZ in its purest and crystalline state is familiarly known as *rock-crystal*, a transparent colourless substance which may be distinguished by the following characters :

Insoluble in all acids.

Infusible alone by the blowpipe, but easily melted with the addition of caustic alkali into a glass.

Giving off no water by calcination.

Crystallizing in the rhombohedral system ; primary form a slightly obtuse rhomb ; inclination of two adjoining faces,  $94^{\circ} 15'$ .

Possessing a certain degree of hardness, considerably greater than that of glass, = 7.

Specific gravity = 2.65.

Lustre, when transparent, vitreous and shining or brilliant.

The cleavages are obtained seldom and with uncertainty, and when they are produced the surfaces are generally somewhat curved, showing a tendency to the conchoidal fracture which characterises most varieties of this mineral.

Primary crystals are of rare occurrence, and are generally

No. 27.



No. 28.



No. 29.



very small. The double six-sided pyramid, also, is seldom an

inch in diameter; but prismatic crystals are found sometimes of very large dimensions. The faces of the pyramids which terminate them are sometimes equal and regular, but in other specimens their size is extremely unequal. It is worthy of remark, that the faces of the prism, however bright, are almost invariably striated transversely to the edges; but those of the pyramids are perfectly smooth and polished. Specimens of quartz frequently exhibit only the pyramids of crystals closely grouped: this is mostly the case when the structure of the mass is radiated.

Crystallized quartz is of various colours; when of a purple tint, it is called amethyst. The ancients valued this gem for the property which their superstition attributed to it, of preserving from intoxication any person who wore it.\*

In Brazil, rock-crystal is found of a clear topaz yellow, of various depths. Smoke-brown crystals, also, which are called Cairn Gorm stones,† are often perfectly transparent; but this colour is sometimes so dark as to render the quartz black and opaque.

Red oxyde of iron dispersed through quartz gives it a bright red colour, but renders it opaque: very perfect crystals of this kind, of a small size, are found at St. Jago de Compostella, in Spain. The neighbourhood of Bristol furnishes specimens of a similar kind, as well as yellow quartz. These ferruginous varieties, called, by the Germans, Eisenkiesel (ironflint), consist sometimes of minute crystals aggregated together, and cemented by ochry oxide of iron, forming a granular mass.

Quartz is occasionally found in crystalline forms belonging to other minerals, such as the cubes of fluorspar, lenticular crystals of gypsum, and dodecahedrons of calcspar: these are called *pseudomorphous* crystals, and have neither transparency nor brilliancy. In some cases, the quartz has formed an incrustation on crystals which have afterwards been removed by

\* *A*, Gr., not, and *methustos* drunk.

† From the mountain Cairn Gorm in Scotland.

decomposition : in others, quartz has filled up, and, as it were, *been cast* in the empty mould left by previous decomposition.

There is also a singular variety of quartz of so spongy a texture, that the multitude of interstices filled with air enable it to float on water : it is called floatstone or nectic quartz, and is found in the calcareous formations near Paris.

Massive quartz of a pale rose colour, strongly translucent, is found in considerable quantity in Bavaria : it is generally much veined, and the colour is unequal. It occurs in other localities, but of inferior beauty. The fracture of *rose quartz* has a somewhat oily lustre, which is observable also in the white massive quartz which forms considerable veins in granite, slate, and other rocks : this kind is nearly or quite opaque.

*Sand* is quartz in minute grains, rounded or angular, sometimes white, but more often coloured reddish or yellowish brown, by oxyde of iron. In *sandstone* the grains are cemented, and intermixed with sometimes siliceous, sometimes argillaceous, and less often by calcareous matter. Of the latter kind, beautiful groups of crystals have been obtained at Fontainebleau, having the form of a rhombohedron of calcspar.

Sandstone is found in Brazil and China, which, when cut into thin slabs, is distinctly flexible.

*Prase\** is quartz rendered nearly opaque, and of a dark green colour, by minute fibres of actinolite penetrating it in all directions. Saxony and Bohemia produce the finest specimens.

The beautiful stone called *aventurine* is quartz of a finely granular structure, reflecting the light from an infinity of brilliant points. There is another kind in which an effect nearly similar arises from the interspersion of minute scales of gold-coloured mica.

The *Cat's Eye*, a gem much prized in the East, is quartz of

\* *Prason*, Greek, a leek ; from its colour.

a closely fibrous structure, so that when cut in a convex form it reflects, like satin spar, a bright band of light with a silky lustre. Its most usual colours are greenish grey or a deep orange inclining to brown. It has been brought from near the Cape of Good Hope; but Ceylon is its chief locality. The finest amethysts are brought from India and Mexico: the largest rock-crystals from Madagascar. Aventurine is often found in rolled pebbles, in Spain, Brittany, and some other places; also, massive (quartz rock) in some parts of the Alps, and Scotland.

*Calcedonic quartz.*—In its chemical characters it nearly resembles rock-crystal: but when calcined it becomes white: its hardness is the same, with greater tenacity. The fracture of all the varieties is conchoidal; in black flint very large and perfect, but seldom having any lustre.

*Calcedony* is in general strongly translucent, sometimes semi-transparent, and of a bluish or yellowish-white colour: more rarely of a pale blue, inclining to lavender. In some rocks it fills the greater part of veins in parallel layers of different shades, alternately translucent and opaque: and it lines, with similar layers, large and small cavities, partly filling their interior with stalactitic and mammellated forms, which are sometimes covered with quartz crystals. Very fine specimens of this kind are obtained from the basaltic and amygdaloidal rocks of the Ferroe Islands and at Oberstein,\* in the Palatinate, where this and many other varieties of calcedony and agate form large veins, and have been quarried for ages.

*Onyx* is a striped calcedony formed of alternate layers of brown and white: this kind has been much esteemed since a very early period for the small sculptures of heads and figures called *cameos*. By the skill of the artist, a brown or a white layer is made to serve as a back ground to the figures which are left in relief on it: and by cutting it to different depths different tints are obtained, suited to the various parts of the

\* About 30 miles southward from Coblenz.

subject. The ancients have left many beautiful works of this description; among others, there is, in the National Museum at Paris, one representing the Apotheosis of Augustus, which measures eleven inches by nine. The Mantuan vase, at Brunswick, supposed to be the largest cameo in existence, is a vessel about seven inches high, shaped like a cream-jug: the figures, which are white and yellow, relieved on a brown ground, represent Ceres and Triptolemus in search of Proserpine.

*Carnelian*\* is a variety of calcedony which has a slightly shining lustre when broken: the white and pale red carnelians are mostly cut from pebbles which have naturally those colours: but when they are *deep red* they have had their tints brightened by exposure to the sun's rays. In its native state, this kind appears of an intense brownish red; and in commerce is generally called *sarde*.† Carnelian pebbles are common in many of the sandy plains of Africa, India, and Asia Minor.

*Sardonyx* implies a striped or onyx calcedony, in which some of the bands are of a red colour.

*Flint* is a well-known variety of compact silica, which occurs chiefly in pebbles or nodules. The black flints that are used for guns are distributed through the chalk in extensive beds: they are often partly calcedonic, or contain crystallized quartz in their cavities. The analyses of flint show that in some instances a minute proportion of carbon, and sometimes of carbonate of lime, is combined with it, supposed to be the remains of organised matter.

*Hornstone* differs from flint chiefly in having a less even texture, and in breaking with a splintery uneven fracture; it constitutes large masses and beds in limestone rocks, and is frequently the petrifying substance of wood and madrepores, in which the organic structure is perfectly distinct, and the colours are sometimes beautifully varied.

\* Carnelian; *carne* from *caro*, Lat., flesh, on account of its colour.

† Sard; either from *Sarx*, Gr., flesh, or Sardis in Lydia, whence it was first obtained.



*Chrysoprase*\* is calcedony of a bright clear green colour, which it derives from a minute portion of the oxyde of nickel. It is peculiar to Lower Silesia. When the colour is equal, and the chrysoprase strongly translucent, it is very beautiful, and much valued as an ornamental stone.

*Bloodstone* or *Heliotrope*† is an intimate mixture of calcedony with a substance called *green earth*, which owes its colour to iron. It is opaque, or nearly so, unless when the mixture of the two minerals is incomplete. The red spots, which it often contains, are jasper; but it is said that the name bloodstone is not derived from these, but from a belief that the stone had power to stanch an effusion of blood.

In *moss agates* and *mochastones*, green earth and other colouring matters occasion dendritic forms which resemble leaves and moss. But *agate* is a name given to many combinations of calcedony, carnelian, quartz, amethyst, and even flint and jasper.

The last-named substance is calcedony or flint coloured by a large proportion of peroxyde of iron. The brown *Egyptian pebbles* are jasper: and bright red and yellow jasper intersected by slender veins of white quartz occurs in masses of great extent in Sicily and the Apennines, besides many other localities. It is sometimes green and deep yellow.

*Flinty slate* or Lydian stone, the *touchstone* of the jewellers, is a kind of flint containing carbonaceous matter: it forms strata of small extent in limestone rocks. It is black, or dark blackish green, and opaque. In order to ascertain the fineness of gold, it is drawn across the stone, and the trace of metal is assayed with acid.

## 2. OPAL‡ (Hydrate of Silica).

\* The ancients gave this name to a stone which, as the name imports, was of a golden green colour (*chrysos* gold): it is doubtful whether the modern chrysoprase is the same substance.

† Pliny speaks of heliotrope as a stone that was used for solar observations: *helios* the sun, and *trope* a turning.

‡ Opal, from *ops* the eye: it was believed, anciently, to have the power of strengthening the sight.

*Precious or noble opal.*—This variety is the one most generally known; its great beauty rendering it a valuable object of research.

It is vitreous, transparent, and has a pale bluish or yellowish tinge; sometimes also it is milky and semi-transparent. It exhibits the most brilliant colours in flashes and sparkles, and sometimes the interior of the stone seems filled with coloured light. It is rather less hard than quartz, and more fragile, particularly when much veined with cracks. Specific gravity 2.11 to 2.3. By calcination it gives off water, of which it contains from 6 to 11 per cent.

Opal sometimes loses partly, or even entirely, its beautiful play of colours, especially if kept in too warm a situation: this is attributed to its losing some of the water essential to its composition: from the same cause it sometimes falls to pieces. The largest and finest specimens are brought from Kaschau in Hungary, where small masses are embedded in a cellular porphyritic rock: they seldom exceed a nut in size; but there is a splendid specimen in the Imperial collection at Vienna, about as large as a man's fist, probably unique. It has been discovered more recently at Honduras.

*Fire opal* (Girasol), a Mexican variety, of a dull yellow or reddish colour, semi-transparent, which reflects in the interior a bright red light.

*Common opal.*—It is so called, when transparent and vitreous, without reflecting the brilliant colours of precious opal.

*Semi-opal or pitch opal* (Opale ferrugineuse; Silex résinite; Jaspé-opale,) occurs of many shades of yellow and red, passing even to dark brown tints, chiefly from the intermixture of peroxyde of iron and alumina, which renders it opaque or feebly translucent. The fracture of semi-opal is conchoidal with a waxy or resinous lustre. It is less hard than quartz, and more brittle; characters which, together with its lustre, will distinguish it from jasper, with which, however, it appears to be sometimes intermixed, passing into it by imperceptible gradations.



*Cacholong*\* is a bluish-white translucent opal, having a vitreous lustre, which is sometimes interstratified with calcedony. The exterior is often in a decomposing state, and is then opaque, with a compact earthy fracture, and from its strong disposition to absorb water will adhere slightly to the tongue.

*Hydrophane*† belongs to this variety; it is opaque and dull; but on being immersed in water it gradually becomes translucent, emitting streams of minute air-bubbles: some pieces, after immersion, present the brilliant colours of precious opal.

*Menilite*, so named from its locality, Menil Montant, near Paris, is of a dark liver colour, sometimes greenish, and occurs in flattened reniform masses, which break with a somewhat slaty structure, and but little lustre.

*Siliceous sinter* (Opale incrustante; Tuf du Geyser): this is a deposition of opaline silica from the water of the boiling springs in Iceland. It is usually of a light grey colour, and varies much in its texture: specimens from the interior of the basin are compact, with a glistening lustre, and appear stratified, as if produced by successive depositions; those from without the basin are generally porous, and inclose fragments of grass and herbs: sometimes it consists of small rounded pearly masses.

*Hyalite* (Muller's Glass) occurs in small rounded masses, as if dropped on the surface of the rock.

## SILICATES.

The genus *silicate* includes the greater part of the species which form the crystalline and aggregated rocks: it also comprises most of the minerals called *precious stones*, and of those which on account of their hardness and beauty are well adapted for ornamental purposes.

Aluminous silicates, either simple or combined with silicates

\* From the river Cach in India.

† *Hudor*, Gr., water, and *ephane* it shines.

of other bases, are the most numerous, and the most abundant of the species.

### 1. KYANITE (Disthène, Sappare, Rhætizite).

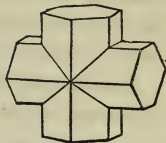
In the mica-schist of St. Gothard and some parts of the Tyrol are found embedded crystals of this mineral: they are prisms, having generally eight sides, rarely with any perfect terminations, and cleavable with ease, parallel to the broader faces of the prism. Kyanite is generally pale blue, sometimes colourless; transparent, with a somewhat pearly lustre, and sufficiently hard to scratch quartz. Specific gravity 3.50. Before the blowpipe, infusible. The variety called Rhætizite is radiated, and sometimes of a pale red or lilac colour.

This mineral contains about 36 per cent. of silica and 64 of alumina—it is a *subsiliate*. It is often associated, in the same rock, with small garnets and the following species.

### 2. GRENATITE (Staurotide; \* Pierre de croix).

The crystals of grenatite, when black, are opaque; but they are often of a dark brownish-red colour, and translucent. They are either rhombic prisms (obtuse angle  $129^{\circ} 20'$ ) or hexagonal, and are frequently grouped so as to form a cross.

The fracture is vitreous, or inclining to resinous. Specific gravity 3.2 to 3.9: hardness, about the same as of kyanite. It has never been found massive, nor in



slender or radiated crystals. Grenatite consists of silica with alumina and peroxyde of iron; but the proportion of the two latter, being isomorphous, varies in different specimens.

3. SILLIMANITE, a combination, in equal proportions, of silica and alumina, which crystallizes in oblique rhombic prisms of a grey colour, has been found only in Connecticut: it is harder than quartz.

*Porcelain Earth* (Kaolin), a white earthy mineral of soft fine texture, has nearly the same composition; but from some

\* *Stauros*, Gr., a cross—Grenatite, from its garnet colour.

localities it contains water. It proceeds from the decomposition of felspar, and in some granitic districts forms extensive beds. Large quantities are obtained at St. Austle's Moor in Cornwall, for the use of the porcelain manufactories.

There are several species of silicate of alumina combined with water, among which are

4. FULLERS' EARTH (*Terre à foulon*), a soft earthy substance of a light brown or greenish grey colour: it falls to pieces in water and readily mixes with it, but does not form a plastic paste.

*Cimolite*, a reddish earth from the island of Cimola in the Archipelago, is a similar substance, and used for the same purposes.

*Bol*, of a bright red colour, which it owes to the peroxyde of iron, and a paler sort obtained from Lemnos, which is much esteemed in the East for its supposed medicinal virtues, are nearly the same substance.

Kollyrite, halloysite, pholerite, lenzinite, and rock soap, so called from its soft soapy texture, belong to this group of species: they all consist of the same constituents; silica, alumina, and water, with small quantities of iron. They do not crystallize, and afford water on being heated in a closed tube.

Lithomarge, of a yellowish or reddish colour, is an earthy substance, which is more abundant, particularly in Saxony, where it fills veins, intermixed with topazes and quartz.

Silicates of Alumina with Glucina.

5. EMERALD (*Smaragd*).

BERYL or aquamarine.

These two minerals are essentially the same substance, and differ only in their colouring matter; which in the emerald is oxyde of chrome, and in the beryl, oxyde of iron. The crystals of both are hexagonal prisms, sometimes modified, but rarely with pyramidal terminations. The prisms of the beryl are often rounded and deeply streaked *laterally*. Their hardness is between 7 and 8, which is greater than that of rock

crystal. When broken, the fracture is generally conchoidal and perfectly vitreous. Composed of silica 68·3, alumina 17·60, glucina 13. The beautiful green of the emerald is always the same, varying only in depth: the beryl is sometimes greenish-blue, sea-green, of different shades of yellow, and occasionally almost colourless. Small and moderate sized crystals are generally transparent: the finest of these come from Brazil and Siberia, where they are associated with quartz and topazes. The opaque beryl is of a greenish or yellowish white colour, and is found in crystals of immense size. In North America prisms four feet in length are said to be found embedded in granite and gneiss rocks; the planes of the prisms being five inches in width. In France, also, near Limoges, they occur of very large size. Both varieties are fusible by the blowpipe, but with some difficulty, into a frothy glass.

No. 32.



6. EUCLASE,\* a very rare mineral, containing 21 per cent. of glucina, has been found only in Brazil and Peru, in transparent crystals of a pale bright green colour. Its form is an oblique prism variously modified. Euclase is characterised by its great brittleness, the facility with which it becomes electric by heat, and the length of time it retains this property. These characters and its crystallization distinguish it from beryl and from the following species.

#### 7. CHRYSOBERYL (Cymophane; Oriental Chrysolite).

Its crystals, derived from a right rectangular prism, are often much modified, and have a tabular appearance. In Connecticut and other parts of the United States, they are embedded along with beryls and garnets. In Brazil and Ceylon they occur as rounded pebbles in the sand of rivers, intermixed with zircons, spinel rubies, and other hard substances which have been washed out of the debris of rocks, their original repository.

\* *Eu*, Gr., easily, and *clasis* a fracture; from its brittleness.

The colour is a very pale green inclining to yellow, sometimes displaying in the interior a bluish floating light. On account of its pleasing colour and great hardness it is employed in jewellery. Its specific gravity, which is 3·6 to 3·7—its greater hardness, which is above that of topaz—its complete infusibility and its crystallization—distinguish it from the two preceding species, and from topaz. It contains 15 or 16 per cent. of glucina.

Silicates of alumina with lime, iron, &c.

#### 8. GARNET.

There are several kinds of garnet, differing from each other in their colour and transparency, and even in their composition, yet having the same crystalline forms and nearly the same hardness; and being all fusible by the blowpipe, and insoluble, or with difficulty soluble, in acids. Most of the varieties afford distinct cleavages parallel to the faces of a rhomboidal dodecahedron, which is therefore to be considered their primary form; their hardness varies from 7 to 7·5, and specific gravity from 3·35 to 4·24.

*Pyrope* (Almandine; Precious garnet) is of a crimson-red, inclining to violet or to brown; generally transparent, or strongly translucent. Crystals, either simple dodecahedrons, or with the edges replaced, or trapezohedrons (figs. 9, 18), which are embedded in rocks, particularly those of the older formations, where it also occurs in roundish grains. Fracture vitreous, and generally conchoidal. Fused by the blowpipe, it becomes a black globule, sometimes semi-metallic, and attractable by the magnet.

*Grossular*.\* This kind of garnet, which contains little or no iron, is of a pale yellowish green, nearly opaque; or transparent and of a bright yellow or orange-colour (topazolite). Colophonite† is a granular variety which occurs principally in veins in Norway and Sweden; and Cinnamonstone (Essonite) resembles it very much in lustre and colour, but is found in

\* Groseille, from its colour.

† Kolophonia (pix), resin; from its colour and lustre.



larger fragments in Ceylon, where it forms part of an aggregate rock. It is sometimes used in jewellery.

In the variety called *aplome*, the faces of the crystals are striated parallel to the edges of a cube.

*Melanite*\* and *Pyreneite*;† black garnets. The former occurs in the Vesuvian lavas and some calcareous rocks of Norway; the latter in the Pyrenees. When fused by the blowpipe they produce a black globule attractable by the magnet. This kind is less hard than the preceding.

*Manganesian garnet* (Spessartine) is of a dull red or reddish-brown colour: manganese, in this kind, replaces the iron. Another variety (from Russia) derives a bright green colour from the oxyde of chrome.

The pyrope or precious garnet is the same as the *carbuncle* of the ancients: the finest are now obtained from Bohemia and Greenland. Garnets frequently occur in metalliferous veins, and small ones have been found in Cornwall.

9. IDOCRASE‡ (Vesuvian; Baikalite; Acanticone). This mineral does not differ much in composition from some of the garnets, consisting of silica, alumina, and lime, with some protoxyde of iron; but its crystals are derived from a square prism. In hardness it is scarcely equal to quartz, and its specific gravity is 3, or 3·4. The prisms are generally modified on all the edges, and often on the angles (fig. 24); those which are of a clear olive-green colour are generally transparent, and sometimes very brilliant; the dark green ones are mostly opaque. Fine crystals are obtained from the vicinity of Lake Baikal; and it is abundant in the lavas and crystalline rocks ejected from Vesuvius, both green and of a dull garnet colour, intermixed with mica and sommite. Fusible into a bead of yellowish glass, transparent or translucent. Most varieties are soluble in the acids more readily than the garnets.

\* *Melas*, Gr., black.

† *Pyreneite*, found in the Pic Eredlitz of the Pyrenees.

‡ *Eidos*, Gr., a form, and *krasis* a mixture—signifying a mixed form; because it resembles several other species in its crystallization.

## 10. SCAPOLITE (Wernerite; Arctizite; Paranthine).

A mineral which is very abundant in some parts of Sweden and Norway in the great tracts of iron ore, where it is often intermixed with garnets, epidote, and some other substances. Its colour is pale grey or greenish grey, and it occurs in slender square prisms either embedded in limestone or in separate groups. Hardness, rather less than that of felspar, 5·5; specific gravity 2·5 to 2·7; fusible with difficulty. It has been found in North America, but not in Great Britain.

The small limpid crystals called *meionite*, which are found in some lavas and in the dolomite of Vesuvius, appear to belong to the same species: their form, hardness, and specific gravity are the same; both consist of silicate of alumina with silicate of lime.

*Thulite*, which is of a rose colour, is very similar in composition; it is found at Tellemarken, in Norway.

*Gehlenite*, another variety, containing more lime, occurs in the Tyrol: infusible.

## 11. EPIDOTE\* (Thallite; Pistacite; Arendahlite).

This mineral crystallizes in modified rhomboidal prisms, which have an unsymmetrical appearance, from the base of the primary being an oblique-angled parallelogram; they are referable to the fifth series of solids. The colour is generally a rich yellow green; varying from transparent, in small bright vitreous crystals, to opaque in granular masses, or when it is disseminated in rocks. Hardness varying from 6 to 7; brittle; specific gravity 3·2 to 3·46. Very large crystals are obtained from the granitic rocks of Norway and Sweden; and beautiful specimens, chiefly of small groups of crystals associated with felspar, from Dauphiné and the Valley of Chamouni.

Epidote contains 38 parts of silica, 27 of alumina, with lime and protoxyde of iron.

\* It received the name Thallite from *Thallos*, Gr., the bud of the olive tree, from its colour; Pistacite from the pistachio nut, also from its colour; arendahlite from Arendahl in Norway.

*Zoisite* is considered to be a variety of the same species, in which the protoxyde of iron is replaced by lime. It is generally of a light grey colour, opaque, rarely crystallized, but cleavable in two directions.

Both kinds, when exposed to the action of the blowpipe, *exfoliate*, or separate into laminæ in the direction of the cleavages; but melt only on the edges.

*Manganesian Epidote* is a variety of a purplish-brown colour, peculiar to St. Marcel, in Piedmont, occurring in manganesian ores.

12. ICLITE (Dichroïte; Indicolite; Cordierite; Peleom; Steinheilite).

The property of *dichroïsm* was first observed in this mineral; and as it was then thought to be peculiar to it, it obtained the name dichroïte. It is rarely crystallized in six and twelve sided prisms; generally disseminated in small masses of irregular form, which are of a deep violet-blue colour when viewed parallel to the axis of crystallization; but in a contrary direction they appear yellowish or smoky grey. In its fracture and lustre, it perfectly resembles glass, but is rather harder than quartz. Differs from all the preceding species in containing 10 per cent. of magnesia.

When sufficiently transparent and of a good colour, it is sometimes used in jewellery, under the name of *water sapphire*. Found principally at Bodenmais in Bavaria; also in Sweden.

Silicates of alumina with an alkali or alkaline earth.

13. FELSPAR (Felspath; Adularia; Orthose\*).

This is a mineral of considerable importance, from its extensive distribution, and the variety it displays in its colour, crystallization, and modes of occurrence. As a constituent of granite it has a perfectly crystalline structure: as the base of porphyries it is compact, of a close, even texture. In granite, the crystals of felspar form groups in cavities or veins, often

\* From *Orthos*, Gr., right or straight.

with other crystallized substances: in porphyry the crystals are embedded separately, as in a paste.

The crystals are derived from a symmetrical oblique rhombic prism, obtuse angle  $119^\circ$ , and yield to cleavage with facility, parallel to its bases and to a plane passing through the shorter diagonal, which is perpendicular to them (No. 33.) It is important to remember this circumstance, because the right-angled cleavage distinguishes felspar from albite, which otherwise resembles it in most particulars, and was long considered to be the same substance.

No. 33.



No. 34.



The maced crystals of felspar, which are of frequent occurrence, do not offer the re-entering angles which we find in the hemitropes of most substances; this is a consequence of the right-angled cleavage, the plane of junction being that which passes through the diagonals. Its most common colours are yellowish and greyish-white, and various shades of flesh-red and brick-red: lustre of the fracture, bright and vitreous: crystals externally from shining to dull. Specific gravity 2.39 to 2.6. Hardness 6. In this character it is very constant. Insoluble in acids, and scarcely fusible by the blowpipe, except on the edges; but with borax it forms a colourless glass. In the transparent colourless varieties, called *adularia*, a bluish opalescent light is often visible, and small pieces, cut and polished, are sold under the name of *moonstone*. Fine specimens of this kind are brought from Mount St. Gothard; and very perfect opaque crystals from Baveno in Piedmont, and Chudleigh in Devonshire. Composed of silica 64.20, alumina 18.40, potash 16.95. Compact felspar, in some of the antique porphyry, is of a green colour; in other varieties, of a dark garnet-red.

Large quantities are used in the manufacture of porcelain, as well as of the decomposed felspar (kaolin).

14. **ALBITE\*** (Cleavelandite; soda felspar) differs from felspar in containing 10 to 12 per cent. of soda, in place of the potash which is a constituent of the former; and in its crystallizations, which belong to the sixth series of solids; the three cleavages all meeting at oblique angles. Yet the general appearance of albite and felspar is so similar, that it is often difficult to distinguish them; their hardness is equal, and their chemical characters the same, except that albite gives a yellow tinge to the blowpipe flame. It forms the basis of granite in several countries, particularly in North America, and is characterised by its almost constant whiteness: the crystals also are generally more tabular, and, when maced, have re-entering angles. The bright transparent crystals generally called *glassy felspar*, which are embedded in some porphyritic rocks and lavas, belong to this species.

*Anorthite*, which occurs crystallized in some lavas, is nearly allied to albite, but contains lime instead of soda; in which it resembles *indianite*, a mineral of a crystalline granular structure from the Carnatic.

14. **LABRADORITE**, a kind of felspar that contains both lime and 4 per cent. of soda, is characterised by the brilliant colours it reflects in certain positions, particularly shades of green and blue: independently of these, its general colour is dark grey. It is rather less infusible than felspar and albite, and may be dissolved in hydrochloric (muriatic) acid.

In Labrador it is found in large masses, and is said to abound in the state of New York.

15. **ANDALUSITE** (Felspath Apyre; Macle; Chiastolite).

A very hard mineral, which, at first sight, appears to resemble some felspars: but it crystallizes in prisms which are very nearly square. It is generally of a pearly grey, but sometimes of a rose colour; faintly translucent, and breaking with a fine-grained fracture, but scarcely any lustre. In hardness, intermediate between quartz and topaz: specific gravity 3.1 to 3.3; in these two characters, and in its crystallization, it differs

\* *Albus*, white.



from felspar. It was first brought from Andalusia, but has since been found in several other places; the crystals are sometimes enveloped in scales of mica.

The variety named *chiastolite* presents a singular structure: the crystals, which are nearly white, and opaque, appear to include, in the centre and at the angles, similar prisms of a dark substance, which is considered to be the same in which they are embedded. Small crystals of this kind are disseminated in the slate of Skiddaw.

No. 35.



#### 16. NEPHELINE (Sommite; Icespar).

A white or yellowish-white semi-transparent mineral which abounds in the Vesuvian lavas, intermixed with idocrase, mica, and other substances. Crystallizes in hexagonal prisms, which are often tabular. Rather less hard than felspar.

*Elaolite*\* (fatstone), a greyish or bluish-green mineral with an oily lustre, which is embedded in the syenite of Norway, appears to be the same substance.

*Gieseckite* and *Pinite of Auvergne*, which also crystallize in 6 and 12-sided prisms, belong to the same group: the latter contain potash; the two former, soda.

#### 17. SPODUMEN (Triphane; Killinite).

This mineral, as well as the following one, contains the alkali *lithia*, which is detected by exposing them with soda to the action of the blowpipe, on a support of platinum foil: the flame will be tinged red, and a brown stain will remain on the platinum.

Its colour is green, or greenish-grey; lustre, pearly or oily; cleavable parallel to the planes of a rhombic prism of  $100^\circ$  and  $80^\circ$ ; specific gravity 3.19; in hardness, intermediate between felspar and quartz. It is abundantly disseminated in the granitic rocks of Sudermania. It differs from felspar and scapolite in chemical characters, specific gravity, and angles of cleavage.

\* *Elacon*, Gr., oil.

18. **PETALITE** (Berzelite; Arfwedsonite) contains more silica and less alumina than the preceding species. When gently heated it becomes phosphorescent, and may with some difficulty be fused; colour white or very pale grey.

19. **OBSIDIAN** (Volcanic glass; Marekanite).

This is a black glassy substance, breaking with a large perfect conchoidal fracture; opaque or slightly translucent on the edges of fragments. On being exposed to the action of the blowpipe, it swells and froths considerably, and is reduced finally to a white enamel. The composition of this species varies: some specimens afford soda, and others potash; they contain 72 to 78 per cent. of silica.

In Mexico, where it is abundant, and was formerly used for knives and mirrors, a variety is found which reflects a chatoyant light of a dark bronze colour. Obsidian is sometimes met with, also, among the ejected matters of modern volcanos. Its chemical properties and the total absence of crystallization distinguish it from smoky quartz.

*Pitchstone* (Retinite) is less vitreous than obsidian, and the conchoidal fracture less bright and perfect: the lustre is resinous, or resembling that of pitch. It presents many colours, principally deep dull greens, brownish red and ochre yellow of different shades; sometimes small bright specks of crystalline felspar are scattered through it. The red and yellow varieties have a great resemblance to semi-opal (ferruginous opal), but may be distinguished from it by not affording water when heated, and by frothing and melting in much the same manner as obsidian. Abundant in some parts of Saxony, Hungary, and the Isle of Arran, besides other localities.

*Pearlstone* (Perlite) differs little in its composition from pitchstone; it consists of rounded angular grains, closely pressed together, generally of a light grey colour, and rather pearly. In *spherulite* the grains are globular, and are sometimes embedded in obsidian.

*Pumice* (Ponce) is another substance belonging to this group, which is more abundant among the productions of recent vol-

canos, as the two former are among those of extinct or ancient ones. It appears to be the *scum* or froth of lava, suddenly cooled by ejection, so as to preserve its spongy form; and is so porous as to float on water. Sometimes, the pores being elongated, it has a fibrous structure. In composition it approaches very nearly to felspar. Being hard and easily reduced to powder, it is much employed for polishing marble, glass, metal, wood, and other materials.

#### 20. LEUCITE (Amphigene; White garnet).

This mineral is common both in ancient and modern lava, in which it is scattered in trapezohedral crystals of a dirty-white colour, usually opaque or translucent, and with a dull surface: internally vitreous; scarcely so hard as felspar. It contains 22 per cent. of potash, but is infusible.

#### 21. PAGODITE (Agalmatolite; Figurestone).

A great part of the images and other carvings that come from China are executed in this stone, which is so soft and unctuous that it resembles, in texture, a compact talc or steatite.

It is opaque, generally reddish or greyish-white, sometimes veined with a deeper tint, with a feebly oily lustre. When heated, it becomes harder, shining, and scaly, but is infusible. Consists of silica 54, alumina 34, potash 6.2, water 4.

#### 22. CHLORITE.

A dark or blackish-green mineral, widely distributed in rocks of the ancient formations, where it forms veins and small beds: in the latter case it has a slaty structure, and is tolerably compact; in the former it is earthy and granular, or composed of minute scales. It is very common in the tin veins of Cornwall, and in similar deposits of ore in other countries. It is often found coating the crystals of quartz, adularia, &c., or in the interior of these substances, resembling moss. Sometimes, but rarely, crystallized in hexagonal plates.

Its composition varies very much: but it consists principally of silica, alumina, protoxyde of iron and water, sometimes with magnesia, sometimes with potash.

## 23. GREEN EARTH.

The minerals thus designated have generally a much brighter colour than chlorite, and never exhibit any trace of crystallization. They all contain water and protoxyde of iron; but the quantity of alumina varies so much, that very different substances appear to be included under the same name.

*Terra verte*, which is much employed as a pigment, occurs in cavities in amygdaloidal rocks; sometimes, as in the neighbourhood of Verona, in considerable masses; sometimes it only lines the cavities, the interior being filled by zeolitic or other minerals.

## ZEOLITES.

The following species, from Natrolite to Prehnite, include those substances which are usually termed *zeolites*; and which, from a resemblance in several of their characters, have been generally placed in the same family or genus. They consist principally of silica, alumina, water, and either some alkali or an alkaline earth. They all afford water on being heated; most of them dissolve in acids and form a gelatine; and the greater part, when heated by the blowpipe, froth and boil violently.

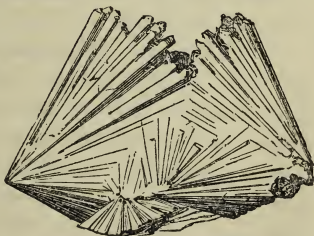
24. NATROLITE } (Mesotype; Radiated Zeolite; Needle  
25. SKOLESITE } Zeolite).

These two species resemble each other so nearly, that they were long confounded together under the name of *mesotype*.

The crystals of both are acicular, or *needle shaped*, and usually grouped in divergent tufts: those of skolesite are square prisms, those of natrolite, rhombic; but the difference of their angles is so small as to be imperceptible to the unassisted eye.

They are colourless and transparent, and when perfect are terminated by four or six planes; but both substances occur in small masses, having a radiated structure and a beautiful pearly lustre.

No. 36.



Natrolite forms also botryoidal masses composed of delicate fibres, radiating from several centres: this variety is sometimes red, or of a fine orange colour. Both species gelatinize when dissolved in acids: natrolite contains soda;\* skolesite, lime: the latter may be distinguished by its twisting and curling like a worm† before the blowpipe.

*Thomsonite* is very similar to the preceding species, but its prisms are rectangular, and in general it is less transparent; sometimes massive.

## 26. STILBITE‡ (Foliated Zeolite).

This is a very beautiful substance, and offers considerable variety in its appearance; but is always characterised by a brilliant pearly lustre. The crystals, which are often hexagonal and very thin, are modified rectangular prisms: sometimes it is massive, or appears in large rhombic prisms, but always exhibits one distinct cleavage: in this it resembles selenite (which will be described hereafter), but is very much harder, about 4.

Stilbite exfoliates before the blowpipe, and afterwards boils and fuses into a glassy substance.

27. HEULANDITE, when massive, is very much like stilbite, but usually of a red colour: its crystals are modified rhombic prisms, and are not generally so thin as those of stilbite.

*Brewsterite*, like the preceding, but generally colourless, and contains a little soda.

## 28. HARMOTOME (Cross-stone; White hyacinth). No. 38.

Differs in composition from the other zeolites, in containing 17 or 18 per cent. of the earth *baryta*: and its crystals, which are modified rectangular prisms, often occur in groups, so arranged as to form a cross. The crystals are always white, and generally translucent. Specific gravity 2·3 or 2·4, which is a little higher than that of the

No. 37.



\* Formerly Natron, whence the name. † *Skolox*, Gr., a worm.

‡ *Stilbé*, Gr., splendour.



preceding minerals. When heated it becomes phosphorescent, and fuses without ebullition.

*Phillipsite* (Abrazite; Gismondine), which occurs in crystallizations precisely similar, in some Vesuvian lavas, differs from harmotome in containing lime in place of baryta.

#### 29. LAUMONITE.

This is a rare substance which has been found in the lead mines of Huelgoet in Brittany. It has been called *efflorescent zeolite* from the alteration it undergoes when exposed to the air; becoming opaque, and, in a short time, falling to pieces. In order to prevent this change, the specimens should, as soon as possible, be dipped into a solution of gum-arabic, and perfectly dried. It is white, cleavable into oblique rhombic prisms, but very fragile.

#### 30. ANALCIME (Cubicite; Sarcolite).

Crystallized in trapezohedrons, or cubes which are modified on the angles (Pl. figs. 17, 18). The crystals vary from the size of a pin's head to two or three inches in diameter: small ones are brilliant and transparent; large ones often opaque and reddish. When viewed in polarized light, the trapezohedral crystals exhibit a singular arrangement of lines of prismatic colours. It is easily fused, a circumstance which will distinguish it from *leucite*.

31. CHABASITE (Chabasie) occurs crystallized in rhombohedrons that are slightly obtuse, sometimes modified on the terminal edges; transparent, colourless, and generally brilliant.

Like Cubasite it is never massive nor fibrous.

#### 32. PREHNITE (Koupholite).

Crystallized prehnite is of rare occurrence. It is sometimes found in thin rhombic or hexagonal plates; but more often massive, imperfectly crystallized on the exterior; or in small lens-shaped masses heaped together: compact, and sometimes fibrous; the fracture has scarcely any lustre. Its most usual colour is sea-green. Hardness little inferior to that of quartz, and specific gravity 2·8 to 3; in both these characters it exceeds considerably the other zeolites. In China it is cut

into slabs for ornament, and carved into images which are brought to Europe under the name of *Oriental Jade*.

The basalt rocks, and others of an igneous origin which are called *amygdaloidal*, are the principal repositories of all this group of species. The cavities of these rocks are sometimes entirely filled by zeolitic substances; others contain radiations or groups of crystals, together with crystals of calcspar, but rarely those of quartz. The Ferroe Isles and Staffa, in particular, afford fine specimens; but harmotome and prehnite occur also in other situations.

Silicates of alumina with fluorine.

There are a few siliceous minerals in which fluorine is combined: the most important are Topaz and Mica.

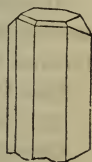
### 33. TOPAZ.

This is a well-known precious stone, which for ornamental purposes is obtained chiefly from Brazil. It occurs there of various shades of yellow and red, also colourless, and pale blue and green. It is always crystallized, or in rounded pebbles. The crystals are derived from a right rhombic prism, and are generally well formed. In different localities, they generally present different modifications which are peculiar to them: thus, in Siberia, the crystals are usually characterised by *two* terminal faces, larger than the others, No. 39; the Saxon topazes have a plane parallel to the base, No. 40; and those from Brazil are mostly terminated by a four-sided pyramid. The sides of the prism are often streaked lengthwise, like those of the beryl; but the topaz may be distinguished by its greater hardness = 8, and by its very perfect and brilliant cleavage parallel to the base: it is also heavier—specific gravity 3.49 to 3.54, and much colder to the touch. It contains 7 or 8 per cent. of fluoric acid. The topaz is generally met with in the cavities and veins of granite rocks. Splendid groups of crystals are

No. 39.



No. 40.



obtained from Siberia, intermixed with crystals of quartz, and sometimes of beryl. In Saxony, Bohemia, and Cornwall, crystallized topazes are found in the metalliferous veins, particularly those which afford tin ore, intermixed with fluor.

The ancients were well acquainted with this gem. It is said that they first found it in an island of the Red Sea; and as it was often concealed by fogs, and difficult to find, they gave it the name *topazion*, from *topazo*, to seek.

Some of the yellow Brazilian topazes, when heated with proper care, acquire a beautiful rose colour; but they are said to lose this tint after some length of time. Of its natural colours, the ruby tint is the most rare.

*Pyrophysalite* is an opaque variety of topaz with a coarse texture, which, like the opaque beryl, occurs in crystals of immense size. One taken from a granite quarry at Finbo, in Sweden, which is preserved at Stockholm, weighs 80 pounds.

*Pycnite* differs but a little from topaz in the proportion of its constituents: it is of a pale straw colour mixed with lilac, and forms columnar masses embedded in quartz, at Altenberg, in Saxony.

34. MICA\* (erroneously Muscovy talc; Muscovy glass).

Mica is a widely distributed mineral; being, like quartz and felspar, a constituent of granite and mica schist, besides its frequent occurrence in other situations. In these rocks we usually see it dispersed in little silvery scales, sometimes very minute; but in the granite of Siberia, and some parts of the United States, transparent plates of mica are obtained from two to three feet in diameter. These plates, if perfect, are either rhombic or hexagonal; and the remarkably perfect cleavage that all varieties of mica possess, is parallel to the base of the crystals.†

\* *Micare*, to shine or glitter.

† Optical investigations show that there are at least three species of mica: the hexagonal plates of some micas are primary crystals; this kind has been distinguished as *hexagonal mica*. In other specimens, the hexagonal prisms are derived from a *rhombic* one, the two acute edges being

Its most common colours are light grey, brown, and olive green; but it is found occasionally black, deep blood-red, and of a bright golden yellow.

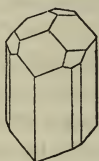
Mica being very elastic and capable of being split into plates of any thinness, it has been much employed in place of glass for lanterns; in Siberia and the Russian navy for windows: and as it will bear considerable heat without injury or alteration, it is often used for the doors of stoves and furnaces; on exposure to a greater heat it becomes opaque and white.

*Lepidolite* is of a lilac colour, massive, and consisting of small aggregated scales.

Silicates containing boracic acid.

35. TOURMALINE (*Schorl*; *Rubellite*). The crystals of tourmaline are generally prismatic with 6, 9, or 12 sides; often somewhat triangular, but rounded and deeply grooved, laterally: perfect terminations are rare, and when they occur the two ends are differently modified. The primary form is a very

No. 41.



No. 42.



obtuse rhombohedron. It is of various colours: the black variety (*schorl*), is perfectly opaque; blue, green, and brown shades are more or less transparent: the rose-coloured has been called *rubellite*. In Massachusetts an interesting variety occurs, of a dark green externally, and the interior of a bright rose colour. Acicular crystals, both black and brown, are sometimes found in radiated tufts, occasionally penetrating other substances.

replaced; and, in a third kind, the prisms are *oblique*. The composition of mica is also variable; some specimens contain potash, some lithia; and the quantity of fluoric acid varies from 2 to 8 per cent.

The tourmaline is distinguished from all substances which, in other respects, it resembles, by the facility with which it becomes electric when heated, exhibiting polarity; and by its remarkable effects on light. A crystal which appears perfectly transparent on looking through it *across the prism*, when held between the eye and the light, and viewed *in the direction of the axis*, will allow but a small quantity of light to pass through it, and in many cases will be found opaque.

Very fine crystals of black tourmaline have been obtained near Chudleigh; they are some inches in length, with brilliant faces. It is very widely distributed, being found in Brazil (of various colours), Ceylon, Siberia (rubellite), the Alps (bright green), North America, &c. The quantity of boracic acid is variable.

36. AXINITE\* (Violet schorl; Thumerstein). The peculiar acute-edged form of its bright glassy crystals distinguishes this mineral from most others. It is of a pale clove-brown, inclining to purple, and transparent, unless when intermixed with chlorite, which often penetrates or coats the crystals, rendering them green and opaque. Hardness, barely equal to that of quartz. It is fusible without much difficulty into a dark green glass, which, in the oxydating flame, becomes black. The finest specimens are brought from St. Cristophe, in Dauphiné.

No. 43.



Silicates containing sulphur or sulphuric acid.

37. LAPIS LAZULI (Lazulite). From this mineral the ultramarine blue is prepared. It has generally a fine granular texture, and occurs intermixed with granular limestone and pyrites, filling small veins and cavities in granitic rocks, in Persia, Thibet, and Bucharina. It is sometimes, but very rarely, crystallized in rhombic dodecahedrons; feebly translucent, and having scarcely any lustre; hardness 5·5; specific gravity 2·5 to 2·9. Soluble in acids, losing, at the same time, its colour, which it is conjectured may be due to some combination of

\* From the axe-shaped crystals.



sulphur with the base of alumina: it loses its colour also by fusion; contains 23 per cent. of soda.

*Häüyne.* A blue mineral which is found embedded in some ancient lavas near the Rhine, and appears to have some analogy with the preceding species.

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Hitherto we have described siliceous minerals of which alumina forms an important constituent: we shall now speak of those in which silica is united with other bases.

The earth zirconia is found in the state of silicate, and combined, in a few rare minerals, with other substances.

38. ZIRCON (Zirconite; Hyacinth; Jargoon). The crystals of this substance are derived from a square prism, and are terminated usually by pyramids, which correspond sometimes with the faces of the prism, sometimes with the edges (Pl. fig. 20, 22, 23). Its specific gravity is 4.4, considerably higher than that of most earthy minerals; hardness, between that of quartz and topaz; lustre oily, approaching to adamantine. The colour of zircon varies through shades of brownish-red and garnet-red to pale yellow, grey and white in the transparent varieties: these are brought chiefly from Ceylon and Pegu, and are used in jewellery under the names of *hyacinth* and *jargoon*, but are not much valued. They are generally small, and are found in the sand of rivers, and more or less rounded. In this manner they occur at Expailly, near the Puy de Dome, in France. The crystals embedded in the syenite of Norway are much larger, sometimes above an inch in length: they are generally dark-red brown, but not transparent.

Zircon, when heated by the blowpipe, loses its colour, but is infusible alone, and even with soda is fused with difficulty. This character, and its high specific gravity, will distinguish it from the garnet, grenatite, and other minerals.

*Eudyalite*, a rare mineral from Greenland, contains zirconia, with silica and soda; its colour is reddish lilac.

39. THORITE is a hydrous silicate of thorina, which has

been found only in the Isle of Lœeven, on the coast of Norway: it is black, vitreous, and hard enough to scratch glass.

40. GADOLINITE is a silicate of yttria, an earth which was first discovered in this mineral, and named from its locality, Ytterby, near Fahlun, in Sweden. It is black or brownish-black, vitreous, and fusible into an opaque glass.

The minerals containing cerium are few and rare, they are found in granite rocks in Sweden and Greenland.

41. CERITE (Cererite) is of a violet or rose colour, much intermixed with grey or brown. It is compact, or fine granular, and opaque. Specific gravity 4.93; infusible alone. It contains 67 per cent of cerium, and 12 of water, with 18 of silica, and 4 of lime and oxyde of iron.

*Cerine* contains a large proportion of iron, but no water.

*Allanite* and *orthite* have nearly the same composition; they are brownish-black, and are embedded in small acicular or columnar masses, sometimes many inches in length. *Pyrorthite* contains carbonaceous matter, which causes it to burn when heated by the blowpipe.

#### CALCAREOUS SILICATES.

42. WOLLASTONITE (Tablespar), and 43. EDELFORSITE, are nearly pure silicates of lime, white or yellowish and translucent: the former (which contains less silica than the latter) has some resemblance to felspar; but may be distinguished by its inferior hardness, and by having no right-angled cleavage. It is found in several localities intermixed with garnets, tremolite, copper pyrites, and sometimes other substances.

44. APOPHYLLITE (Fisheye-stone). The white, pearly crystals of this mineral might, at first sight, be mistaken for those of zeolite, but they are square prisms, either perfect or having the angles replaced by triangular planes, which are sometimes increased so as to produce a pyramid. It is also rather harder than the zeolites, though scratched by felspar; froths before the blowpipe, and gelatinizes in acid. It is a silicate of

lime and potash, with water, and occurs both in the same situations as stilbite, &c., and in the neighbourhood of the great deposits of magnetic iron in Sweden and Norway.

### MAGNESIAN SILICATES.

These, when not combined with lime, are characterised by great infusibility, are very difficultly soluble in acids, and many of them are very soft and unctuous.

45. **CHRYSLITE** (Peridot ; Olivine). A gem of a yellowish-green colour, sometimes passing to a pale yellow-brown, which is disseminated in some basaltic rocks in small transparent grains, and more rarely in crystals, which are modified rectangular prisms. It breaks with a vitreous fracture, is scarcely so hard as quartz, and infusible without the addition of a flux : these two characters distinguish it from the beryl and chrysoberyl. It is a silicate of magnesia and iron. The vitreous grains observed in basalt were named *olivine* from their colour, before it was known that they were the same substance as chrysolite ; in some of these formations, it occurs in granular masses of considerable size, as at Vivarais, and the banks of the Rhine. But the most remarkable situation in which chrysolite has been found, is in the cavities of the celebrated mass of meteoric iron in Siberia, and it is now ascertained that it forms a large proportion of some other masses which are derived from the same source.

The finest chrysolites are brought from Constantinople, cut and polished, and it is not known in Europe, whence they are originally obtained.

46. **CHONDRODITE** (Brucite). A silicate of magnesia, containing fluoric acid, which is found in translucent grains of a yellowish or brownish colour, at Pargas (Finland) and New Jersey (United States), embedded in limestone.

47. **TALC** generally occurs in foliated masses, white, or of some shade of green, having a very pearly lustre. The folia have no regular form, but are often divergent or stellated. Talc, though flexible, is not elastic, which is a distinction

between it and mica; the laminæ are also much more tender than those of mica, being easily scratched by the nail (No. 1, in the scale of hardness), and it is soft and unctuous to the touch. Talc is a silicate of magnesia, combined sometimes with hydrate of magnesia in variable quantity.

The finest specimens are obtained from the Alps of Savoy and Piedmont. It is said also to have been found in the United States of a rose colour, and blue.

*French chalk* is a variety of talc in which the folia are so small that it has a somewhat granular texture and a glimmering lustre.

*Steatite* or *soapstone* has the same composition; it has a more compact and earthy appearance than French chalk, and a very soapy or unctuous feel. It forms veins in serpentine, and is quarried and applied to many purposes; as, in mixing with clay, &c., for the manufacture of porcelain, of which it increases the transparency, and, in powder, for diminishing the friction of machinery. Pencils also are made of it, instead of slate; and it is very efficacious in removing spots of grease from silk and cloth. In France it is called *Craie de Briançon*.

*Potstone* (Pierre ollaire) is of a dark grey or greyish-green, has a somewhat slaty structure, and is opaque. It is very infusible, and indeed appears quite unalterable by heat; a quality which, combined with its softness when first taken from the quarry, and its hardening by exposure to the air, renders it an excellent material for many objects of domestic use, such as ovens, stoves, pots, &c. They are esteemed not only for their indestructibility, but because they can never give any bad taste or quality to the food. It is quarried at several places in Piedmont; particularly near Chiavenna and the Lake of Como; also in the Valais: it is extensively manufactured in the Val Sesia, not far from Mount Rosa; and at Zœblitz in Saxony. The pieces of a fine even texture are turned by the lathe into teapots, basins, &c. If a vessel of potstone, after being used for some time, has absorbed much



grease, it is usual to make it red hot, a process which renders it as clean as new, and without injury.

Pliny speaks of this stone, and describes its application to the same purposes as at present: but calls it *Lapis Siphnius*, because at that time it was obtained from the Isle of Siphnos, now Siphanto. At the convent of the Great St. Bernard there is a stove of potstone.

48. SERPENTINE (Ophite). A compact substance, very tough, breaking with an uneven fracture and waxy lustre, or dull and earthy. Generally of a dark green colour intermixed with black, and sometimes with red and brown: opaque, except the kind called *precious serpentine*, which, when cut into thin slabs, is semi-transparent: it is of a rich warm green colour and often contains embedded garnets: this sort is found at Baireuth in Austria.

Serpentine differs very much in hardness, but all specimens are easily scratched by a knife, and many by calcspar. Notwithstanding this, it is much employed in slabs for ornamental purposes; particularly those varieties in which, like the *verde antique*, the dark colours are relieved by spots and veins of white calcspar. Handsome serpentine is quarried at Anglesea, and used under the name of Mona marble.

*Marmolite* is a foliated serpentine, containing less silica than the preceding; both species give off water when heated.

49. MEERSCHAUM (Magnesite; Écume de Mer) is an earthy opaque substance resembling white clay, but dry and harsh to the touch; partially soluble in acids, and affording much water by calcination.

It is well known as a material of which pipes are made; it is extensively quarried for that purpose in Asia Minor, particularly at the foot of Mount Olympus, and in the Island of Negropont. In some places it is used instead of soap for washing linen, and is said to form a good lather when mixed with water.

The adhesive slate (*schiste happante*) in which menilite is embedded, is a mixture of meerschaum with argillaceous matter.



50. **DIALLAGE.** This mineral, which has not been found crystallized, is embedded in serpentine, and, occasionally, other rocks, in fragments which are cleavable; there are several varieties, which are composed chiefly of silica, magnesia, and the protoxyde of iron, with only a trace of lime.

*Bronzite* is of a greyish brown colour, translucent and, as its name implies, with submetallic lustre; specific gravity 3·25. It is found in France, department of the Higher Alps.

*Hypersthene*\* (Labrador Hornblende); of a dark brown colour, reflecting a coppery lustre. The laminæ are sometimes so much bent, that it has the appearance of a woody structure. Specific gravity 3·3: this mineral is much harder than the preceding: its principal locality is Labrador.

*Anthophyllite* has generally a fibrous structure, and a pale hair-brown colour; lustre, slightly metallic: distinguished from bronzite by its brittleness.

51. **SCHILLERSPAR** (Diallage-euphotide). Like the preceding species, it occurs with a lamellar structure, but no external crystallization; embedded in serpentine, or in rocks containing albite. Its colour is dark olive or greyish green; hardness about 4. It differs in composition from diallage in containing 10 or 12 per cent. of water: when exposed to the action of the blowpipe, it becomes magnetic, but is scarcely fusible on the edges.

*Smaragdite*† contains 7 per cent. of the oxyde of chrome, which gives it a fine clear green colour. It has a laminated structure, is very translucent and brittle: fusible into a blackish glass.

The rocks consisting of smaragdite intermixed with albite, are cut into slabs, and when polished are very beautiful. In Corsica it is abundant, and is known by the name of *verde di Corsica duro*: it is found also in rolled masses on the borders of the Lake of Geneva.

52. **NEPHRITE** (Axestone; Jade). A compact substance,

\* *Huper* above, and *sthenos* strength, from its remarkable toughness.

† *Smaragdus* the emerald, from its colour.

generally of a green colour, but sometimes grey, or reddish. It breaks with an uneven but fine-grained fracture, and has a feeble oily lustre. Laminæ of a silvery talc are sometimes dispersed through it. Hardness variable, sometimes above that of quartz, and exceedingly tenacious. Specific gravity about 3.

Some of the finest specimens of dark green nephrite are the war hatchets of the New Zealanders. This variety appears to be the same which is found near the banks of the Oronooko, but the precise locality is unknown. It is cut into ornaments which are worn as amulets by the Indians, and even by the Spaniards of that country. It is sometimes called Amazon-stone.

Silicates of lime with magnesia, &c.

53. **AUGITE** (Pyroxene). This species may be distinguished into two kinds: the *white* augite, consisting essentially of the bisilicates of lime and magnesia; the *black* and dark green, in which these bases are partly replaced by the protoxyde of iron, which is isomorphous with them: the pale varieties contain very little iron. The crystals of all kinds are derived from an oblique rhombic prism; obtuse angle,  $92^{\circ} 55'$ . Specific gravity from 3.1 to 3.34; hardness 5 to 6.

*Diopside*, *malacolite*, *alalite*, *mussite*,\* are denominations of white and greenish-white augite. The crystals are often semi-transparent, with bright glassy faces. Fusible by the blowpipe into a colourless, or nearly colourless, glass. The best specimens of this kind are obtained from some parts of Piedmont and the Tyrol, where they form groups with bright red garnets and mica.

No. 44.



*Fassaite*,\* or pyrgomme, is of a clear dark green colour, usually in small distinct crystals, sometimes embedded in calc-spar.

*Sahlite* is massive, generally of a light greyish green, translucent and cleavable, affording good surfaces.

\* Named from the valleys of Ala and Mussa in Piedmont, and Fassa in Tyrol.

*Coccolite*\* is granular augite; the grains are usually compressed together, and not dispersed in another substance. The two latter varieties occur at Sahla, in Sweden, with pearly calcspar and sometimes with scapolite, but they never have the yellow-green colour of epidote.

*Hedenbergite*, *black augite*, *basaltic augite*, is rarely massive: the crystals are often maced; colour blackish green, black, or brown: streak and powder greenish or brownish black. Fusible by the blowpipe into a black or dark green glass.

The crystals of this augite are abundant in some kinds of lava, and especially in the ancient lavas of Auvergne. It is an abundant as well as a widely distributed mineral, being a component of some kinds of basalt (*dolerite*); it is there intimately mixed with albite, or with labradorite, and gives the dark colour peculiar to that rock.

No. 45.



54. HORNBLLENDE (Amphibole). This species is subdivided, in the same manner as augite: the white varieties consist of silicates of lime and magnesia, with scarcely a trace of iron; the dark ones contain a large proportion of the latter base: but both the light and dark-coloured hornblende contain less lime than augites of the same colour. The crystals are derived from an oblique rhombic prism; obtuse angle,  $126^{\circ}$  to  $127^{\circ}$ . The black or blackish green variety, commonly called *hornblende*, is by far the most abundant. Its crystals are generally short and thick, and have some resemblance to those of the black augite. They are found principally in basalt and other similar rocks; but the angle of the prism (and of cleavage) is much more obtuse in hornblende. It is often massive, and embedded in felspar and albite; intermixed with the former, it constitutes the rock called *greenstone*; with the latter, a very similar one called *diorite*: in both these we find the fragments of hornblende with a crystalline structure, of all sizes, from several inches in length to particles so small as to be undistinguishable to the naked eye. It is sometimes fibrous, having

\* Coccus, a grain.

the appearance of black tourmaline; but that mineral breaks with a perfectly vitreous fracture, and hornblende with distinct cleavage: it is particularly tough, also, and difficult to break.

*Actinolite*\* (actinote) is of various shades of green, and crystallizes in brilliant slender prisms, with four, six, or eight sides; often acicular and radiated; and penetrating quartz and other substances; sometimes in masses of delicate glassy fibres, which are very brittle.

*Pargosite* is the same substance, but generally in small separate crystals embedded in limestone, at Pargas, in Finland.

*Tremolite*, or grammatite, occurs in white or greyish crystals, of which the faces are bright and glassy; or it forms fibrous and radiated masses, sometimes with a pale green or lilac tint, and generally translucent: these masses are embedded in the dolomite of St. Gothard, the crystalline limestone of Sweden, &c. The specific gravity of tremolite is 2·9 to 3: of black hornblende about 3·3. In hardness they are rather inferior to felspar.

*Asbest*,† *Amianth*, *Byssolite*. This remarkable substance is a fibrous variety of hornblende or tremolite, of so soft a texture that it can be spun and woven like flax: and from its incombustible nature, the cloth made of it may be cleansed when dirty, by burning it. The ancients are believed to have wrapped their dead in cloth made of asbestos, previously to placing them on the funeral pile, in order to preserve their ashes distinct from those of the wood. They used it also for the wicks of their perpetual lamps: it is applied to the same purpose by the Greenlanders of the present day. Charlemagne is said to

\* *Actin* a ray of the sun.

† *Asbestos* unconsumed, *amiantos* undefiled. The singular properties of this mineral, soft as flax, but perfectly incombustible, have given rise to some strange ideas as to its origin. Marco Polo, who visited the East in the 13th century, speaking of the mountains of Tartary, says, "There is found there a substance of the nature of the Salamander, which, being woven, is incombustible." The Chinese appear to have imagined that the asbestos-cloth may have been manufactured "of the hair of certain rats that lived in the flames of certain volcanos."

have possessed a tablecloth woven of amianthus, which he used, after dinner, to throw on the fire to cleanse it, for the amusement of his guests. In some parts of the Pyrenees, girdles are made of the same substance, intermingled with silver threads, which are highly prized, not only for their beauty, but as a sort of charm. In Russia, attempts have been made to manufacture paper from amianth, but they were unsuccessful. The *ligniform* or *wood-like asbest*, though it consists entirely of delicate fibres, is so compact, as to admit of being cut and polished: in this state it resembles petrified wood. The colours are generally brown, inclining to green or grey.

In *Mountain leather* the fibres are very fine, and so interlaced as to produce a texture resembling kid leather.

*Mountain* or *rock cork* is spongy and elastic; its numerous cavities enable it to float like vegetable cork. All these substances form little veins in serpentine rocks, and sometimes in greenstone, often associated with talc. Fine specimens of the wood asbestos come from Sterzing, in the Tyrol. The localities of amianth are numerous; at one time it was found so abundantly in Corsica, as to be used instead of tow for packing minerals. Asbest is sometimes enclosed in rock crystal, and gives it the appearance of cat's-eye.

It must be observed, however, that some specimens of asbest are found to be *augite*; this is generally the case when they occur in rocks of which augite is a constituent, or where it is abundant: in hornblende and tremolitic rocks, on the contrary, the asbest is usually of that species: but it is frequently impossible, without analysis, to know to which they should be referred.

Ferruginous silicates with lime, &c.

55. YENITE (Ilvaite; Lievrite). A calcareous silicate of iron, which crystallizes in right rhombic prisms variously modified. Colour generally intense brown; lustre approaching to metallic. It may be fused without difficulty into a black globule; and in acids forms a jelly. Fine specimens, both crystallized and massive, are obtained in the Isle of Elba, Rio



la Marina, and it is found also in Norway and Siberia. There are several other silicates of iron, some of them containing water, as *Nontronite* and *Hisingerite*—but they are unimportant, and generally rare and little known.

Manganesian.

56. RHODONITE (Manganese spar; Rose Manganese) is of a beautiful rose colour, inclining sometimes to violet: mostly compact or fine granular; and generally translucent. It is sufficiently hard and tenacious to strike sparks with steel. Specific gravity, 3.6 to 3.9. Heated by the blowpipe, it becomes of a dark brown colour, and when fused with borax forms a deep rose-coloured enamel. The finest specimens are brought from the mines near Ekaterinenburg, in Siberia. Being susceptible of a good polish, it is sought for to cut into slabs for boxes, and for inlaying.

*Photizite* and *Allagite* differ a little from this species in the proportions of their constituents: the former is yellow or yellowish grey; the latter inclining to green or brown.

Zinc.

57. ELECTRIC CALAMINE is silica combined with zinc and a small quantity of water. It received this name from becoming electric when heated; it becomes at the same time phosphorescent. It is sometimes found in very small transparent crystals, often radiated, sometimes with a fibrous structure; also in stalactitic forms, and with an earthy texture. It occurs with other ores of zinc, both in Great Britain and other countries, and is used for the production of both zinc and brass.

Copper.

58. CHRYSOCOLLE. This is a bright green substance, which does not crystallize, but often forms a coating on other ores of copper. It is translucent, somewhat vitreous in its appearance, and very brittle. By calcination it gives off water, and becomes black.

*Diopase* is another silicate of copper, of a fine emerald green colour; in transparent crystals, extremely rare.

## FAMILY II.—BORIDES.

## Genus I. OXYDE OF BORON.

This family is of little importance. Boracic acid (or Oxyde of Boron) is contained in solution in the water of some lakes in Tuscany; and is found deposited on their borders in the form of white or yellowish pearly scales. It is particularly abundant near Sasso, whence it has been called Sassoline. Its taste is slightly saline and acid: it melts in the flame of a candle, in consequence of the large quantity of water it contains.

## Genus II. BORATES.

1. BORAX, or Boracic acid combined with soda, is a substance much used in various manufactures. It is found crystallized in modified prisms, which are white and transparent; soluble, with a sweetish alkaline taste. It was brought to Europe originally from Thibet, where it was obtained in considerable quantity from the edges and shallow parts of a salt lake: at present it is manufactured chiefly from boracic acid.

2. BORACITE consists of boracic acid, combined with magnesia. It has been found only in small and distinct crystals, embedded in gypsum, in Saxony, and at Kiel in No. 46. Holstein: these are cubes, of which the alternate angles only are replaced; sometimes by one, sometimes by three planes; this peculiarity distinguishes it from all other minerals which crystallize in cubes, that in any degree resemble it.



Boracic acid combined with lime and silica, forms

3. DATHOLITE, a colourless vitreous mineral, crystallizing in right rhombic prisms; but the crystals are small and rarely distinct. In some of its chemical characters it resembles the zeolites, but in fusing it tinges the flame green.

*Botryolite* is nearly the same in composition, but it does not crystallize. Both minerals are found at Arendahl in Norway.

## FAMILY III.—CARBONIDES.

## Genus I. CARBON.

Carbon and its combinations afford several minerals that are interesting, either on account of their utility or their beauty; among the latter we find the

1. **DIAMOND.** This gem, so highly valued, is carbon in a state of perfect purity; that element which enters so largely into the composition of all animal and vegetable matter. It is always found crystallized, and its forms belong to the cubic series: the most common are octahedrons with the edges replaced, and dodecahedrons; and in most instances the secondary faces, however brilliant, are convex. Notwithstanding its extreme hardness, far greater than that of any other known substance, the diamond yields readily to cleavage, parallel to the planes of the regular octahedron. Its specific gravity is 3.48 to 3.55. It is found of many colours, rose, yellow, blue, green, and brown; bright tints, however, except yellow, are rare; though it is generally transparent, unless when very dark coloured; rarely with a milky or opaline appearance. Its brilliancy is very great, in consequence of its uncommonly high refractive power, and its lustre is termed *adamantine*.

No. 47.



No. 48.



The fact of the diamond being carbon, is proved by its combustion, which takes place when it is exposed to a very high temperature: like charcoal, it is converted, by this operation, into carbonic acid.

It is still sometimes asserted that diamonds, after being exposed for some time to the sun's light, if taken into a dark room, will shine, giving out the rays they have absorbed; but the account seems to have originated in an eastern tradition.

Until the beginning of the eighteenth century, diamonds were obtained only from India, where they are still found in several provinces, particularly that of Golconda in Hydrabad,

and the island of Borneo : but in 1728 the existence of diamonds in Brazil became known to some Portuguese colonists, who discovered the mines at Serro do Frio. They have since been found in other places, generally within ten or twelve leagues of the city of Tejuco. The most extensive mines are those of Mandanga on the river Jighitonhona : it is said also that the Serro San Antonio and the district of Rio Plata are rich in diamonds. Still more lately, in 1829, diamonds were discovered on the western side of the Ural Mountains, accompanied, as in Brazil, by grains of gold, and sometimes of platina.

Both in India and South America the diamonds are found in the beds of streams, mixed with sand and quartz pebbles and grains of gold, sometimes all connected together by brown ochry clay : the crystals are often so much enveloped by this crust, as not to be visible till they are separated from it by washing.

Diamonds were valued by the ancients, doubtless on account of their hardness and scarcity ; for they were unable to cut or even to polish them. The clasp of Charlemagne's mantle, which is preserved in the Museum of Paris, was adorned with four uncut diamonds of octahedral form. But about the middle of the fifteenth century, a young man of Bruges, observing the effect of rubbing two diamonds together, made the experiment of cutting them by means of *diamond-dust*, and succeeded : the same method is employed at the present day. Diamond cutters avail themselves also of the cleavable structure of the diamond to remove some parts, and thus reduce them to something like the desired form. The octahedral points, which cannot be removed in this manner, are reduced by rubbing them against another diamond, each being fixed, by means of cement, to the end of a stick. When a facet is thus produced, the position of the diamond is changed, and it undergoes the same process in another direction : and when it has assumed the proper form, the facets are polished on the *skive* ; a thin circular plate of soft iron, charged with diamond

powder, which is made to revolve rapidly; the diamond being fixed by solder to a stick, and pressed moderately against it. Such as are unfit for cutting are called *bort*: and of these, a great part is broken up, reduced to powder, and sold to lapidaries: splinters are sharpened to a fine point, and used as drills for other hard substances, and for engraving on gems and agates; and many are set in metal, and used by glaziers to cut glass: for this purpose, only the natural crystals are available, and particularly such as have the edges convex.

Diamonds have also been used with advantage for the lenses of microscopes, and are constantly employed by engravers, instead of steel points, for ruling lines to produce flat tints.

Diamonds of a large size, that is to say, above ten or twelve carats,\* are rare; though some few have been found weighing upwards of a hundred. The most celebrated ones, that are at present in the possession of different sovereigns, have already been described by so many authors, that the reader is referred to their works for an account of them.†

2. GRAPHITE (Plumbago; Blacklead; Mine de plomb). The substance called blacklead is well known to most persons; but few perhaps are aware, that when they make use of a blacklead pencil they draw with a substance which is nearly identical with the Diamond. It appears to be carbon, differing from it, when pure, only in the state of aggregation of its particles: it often contains a small quantity of earthy matter, or of iron; but as the latter amounts to only 1 or 2 per cent., both are now generally considered as accidental impurities. Graphite has always a metallic lustre, with sometimes a fine scaly structure, and soils the fingers when handled. Specific gravity, 2 to 2.45.

The best graphite is that of Cumberland, but it is found in many other parts of Europe, and large blocks have lately been

\* The carat is a weight used by diamond merchants, which is rather less than four grains troy.

† Particularly "Minerals and their Uses, in a Series of Letters to a Lady," by J. R. Jackson, Esq.



imported from Ceylon: it occurs also in Canada, and at several places in the United States; generally in detached masses of various sizes, or small grains, embedded in gneiss or slate rocks.

For the best pencils, it is used without any other preparation than that of sawing it into thin strips, which are afterwards enclosed in wood, or formed into thin rods for the ever-pointed pencils: but great numbers of pencils of inferior quality are made of a mixture composed of blacklead dust, intermixed with clay, and sometimes with lampblack, or sulphuret of antimony.

## Genus II. CARBURET.

1. CARBURETTED HYDROGEN. This is the gas called by miners *fire-damp*. It is formed in abundance in coal-mines, and, being highly inflammable, on the approach of a lighted candle or lamp it ignites and explodes, producing serious accidents, and often loss of life.

2. NAPHTHA (mineral oil) is a limpid fluid of a yellowish colour, much lighter than water, and very inflammable; on exposure to the air, it thickens and becomes darker. There are springs of this liquid in several countries; as in Albania, and at Amiano near Parma, where it is collected and employed for lighting the city of Parma. On the western shores of the Caspian, where the soil is light and sandy, on making a small hole to the depth of a few inches, and inserting a tube, naphtha may be immediately obtained: and at Baku, in the north of Persia, are the remains of temples built by the ancient inhabitants, fire-worshippers, who kept it constantly burning, believing it to be of sacred origin.

*Petroleum* (liquid bitumen) is naphtha, containing bitumen; it is nearly black, and much thicker than naphtha. It oozes out of rocks in the neighbourhood of coal beds, and hardens by exposure to the air, from the evaporation of the naphtha. At Rangoon, in the kingdom of Ava, this substance is found in great abundance: the pits, whence it is obtained, yield above 400,000 hogshheads annually. It is common in many other

countries, both of Asia and Europe, and found in several parts of North America. The bricks of which Babylon was built, were cemented by petroleum in place of mortar: the Egyptians employed it in the process of embalming; and to the present day, the boats on the Tigris are *tarred* with petroleum.

*Asphaltum* is another variety of bitumen, which is solid and hard, breaking generally with a glossy conchoidal fracture, and very much resembling vegetable pitch. When pure it will float on water, and in this manner is collected from the Dead Sea; but it is often mixed with earthy matter, and is then heavier than water.

In the island of Trinidad there is a very remarkable small lake, which appears to be entirely filled with asphaltum. Near the shore it is solid and hard, but at a short distance it is warm and soft, and increases in temperature towards the centre, where it seems to be in a boiling state; and even the surface of the solid part seems to have been cooled suddenly when in a state of ebullition.

The asphalt of Seyssel, and other parts of France and Switzerland, used for some years past in paving, is of the same kind.\*

3. COAL consists chiefly of carbon, which in different kinds is united with various proportions of bitumen.

*Anthracite* (mineral charcoal or glance coal) is the kind which contains the smallest amount of hydrogen, and no bitumen; for this reason it burns without flame or smoke, and with difficulty. It is used as fuel in lime-kilns and furnaces. It is hard, dry to the touch, and shining.

*Common or slaty coal* (houille) differs from the above in containing bitumen: this is the substance, which, when coal has been a short time on the fire, we see oozing and boiling out of the cracks in the manner of pitch. Coal is a brittle mineral, and most varieties have a tendency to break into somewhat

\* Naphtha is found to consist wholly of carbon and hydrogen: petroleum and asphaltum appear to contain oxygen likewise, and traces of azote. Naphtha is purified from the bitumen it generally contains, by distillation.

rectangular fragments. Its specific gravity is not above 1·5; and the hardness, which is less than that of anthracite, is variable.

*Cannel coal* is very compact, with an even texture; and breaking with a large conchoidal fracture and scarcely any lustre. It burns readily, and with so bright a flame, that thin pieces have been used as candles. It is sometimes turned or cut into boxes, inkstands, and other objects, but it does not receive a very brilliant polish.

This is an excellent sort of coal for burning, because it contains more hydrogen than any other: this gas, combined with a portion of carbon, is obtained from coal by distillation, and is the gas employed for lighting streets and houses: the bitumen, also, which is volatile at a certain heat, is obtained by the same process, and is used under the name of *coal tar*.

These, and other varieties of coal, form extensive beds, interstratified with other rocks, principally sandstone and slaty clay, or shale: the coal strata are generally much thinner than the intervening beds, and often appear only at considerable intervals, after several repetitions of them.

*Lignite, bituminized wood, or brown coal*, differs from black coal in having a woody structure, and in containing a different sort of bitumen, which burns with a peculiar odour: it appears to be coal of imperfect or more recent formation than the other kind. There is a considerable deposit of it near Bovey, in Devonshire, and it is common in many other countries.

*Jet* is a very compact lignite, which, when broken, has a brilliant lustre: the original woody structure may, notwithstanding, often be perceived; and it is even found sometimes in the form of branches and stems of trees. Large quantities of jet are found in the Department of Aude, in the South of France; and several hundred persons formerly gained a living in that part, by turning and carving it for ornaments; but the consumption is now much diminished.

*Cologne earth*, which is used for painting, is a decomposing variety of brown coal, and in the vicinity of Cologne it is damped and pressed into moulds and used as fuel.

4. AMBER (Succin). It occurs in irregular roundish pieces from the size of a nut to masses weighing several pounds, which are generally embedded in lignite or in the sandy strata belonging to the same formation. The colour of transparent varieties is yellow or brown; the opaque specimens are often white. Specific gravity 1 to 1.18; hardness 2 to 2.5.

Amber is sometimes found containing insects, which seems to confirm the supposition that it is, originally, a vegetable resin, hardened, and, perhaps otherwise altered by time and situation. Amber may be distinguished from substances which are sold under that name, by its greater hardness and tenacity, and its becoming more strongly electric by friction. It burns with an agreeable odour.

*Retinasphalte* is a mineral resin of a light brown colour, nearly opaque, sometimes earthy, which occurs in lignite: it is soluble in alcohol.

*Highgate resin* or *fossil copal*, *schiererite*, *hatchetine* and *dyso-dyle*, are all minerals of a resinous nature, generally occurring with lignite, or near it.

### Genus III. MELLATE.

MELLITE, which has also been called *honeystone*, from its colour, occurs in square octahedrons, resembling bits of yellow resin, embedded in lignite, in Thuringia. It consists of alumina and water, united to mellitic acid, which contains, by weight, about equal quantities of carbon and oxygen. Burns to a white ash.

### Genus IV. OXYDE OF CARBON.

CARBONIC ACID (Fixed Air) exists in some mineral waters, giving them the sparkling pungency of artificial soda water. It destroys life and combustion, and being much heavier than the air of the atmosphere it is dangerous to descend into caverns where it is naturally generated: the Grotto del Cane, near Naples, is celebrated for the effects produced by the fixed air, which fills it to a level with the entrance. Its compounds are comprised in the next genus.

## Genus V. CARBONATE.

The minerals comprised in this genus are characterised by their solubility in acids, at the same time disengaging carbonic acid by effervescence; some, however, require heat to effect their solution.

1. NATRON (Carbonate of Soda) occurs in nature as a powder or incrustation, which, if pure, is white; otherwise, yellowish or grey. It is perfectly soluble, and its alkaline taste is generally known: crystals obtained artificially are transparent at first, but effloresce by exposure to the air, and are soon covered with a white pulverulent coating.

Natron is abundant in some of the lakes of Egypt, Arabia, and India; and in Hungary, during the summer months, the ground often becomes white with this salt, as if covered with snow.

2. TRONA, which contains less water and more carbonic acid, does not effloresce. Between Tripoli and Fezzan in Africa, it forms a thin bed of a fibrous structure, from which hundreds of tons are extracted annually. It is found likewise in Columbia.

3. CARBONATE OF LIME. Few minerals present so great a variety in their appearance, and none afford so many crystallizations.

*Calcspär*, which we have mentioned more than once, is carbonate of lime in its purest state: its specific gravity is 2·6 to 2·73; hardness 3. Its crystals are derived from a rhombohedron, No. 49, which is easily obtained by cleavage, the planes meeting at an inclination of  $105^{\circ} 5'$ .

The annexed figures, No. 3, p. 7, and Nos. 5, 8, 10, p. 8,

No. 49.



No. 50.



No. 51.





occur more frequently than most others; No. 4 and 7, p. 8, also, are not uncommon.

Calcspar is generally transparent or translucent; the faces of the crystals, sometimes very brilliant; but it is remarkable that the bases of the hexagonal prisms are alway opaque. It is sometimes perfectly colourless, often of a topaz or honey-yellow, greyish, or reddish. When pure it consists of 56·3 of lime, and 43·7 of carbonic acid: but it frequently contains some carbonate of iron or magnesia, or is coloured by oxyde of iron and clay.

Exposed to the blowpipe, carbonate of lime does not swell nor fall to powder, but becomes white and caustic; it is then *quick lime*: some varieties are phosphorescent when heated, and shine with a pale yellow light. Crystals of calcspar are rarely found *embedded* in other rocks, as is so commonly the case with garnets, tourmalines, and many other minerals; but they form groups in the clefts of calcareous rocks, and the cavities of metalliferous veins. The copper mines of Derbyshire and Leicestershire, and the lead mines of Durham, afford beautiful specimens; and very fine crystallizations occur in the silver mines of the Hartz Forest, particularly of the hexagonal prism.

*Satinspar* consists of fine parallel fibres, either straight or waved, and has a silky lustre; it fills small veins in limestone rocks, the fibres lying across the vein.

*Limestone* is a general name applied to all massive varieties of carbonate of lime that form beds of great extent, or mountains. Some kinds are granular, with a highly crystalline structure, such as the marbles of Paros and Carrara, which are employed in sculpture: they are likewise called *sacharoïde*, from their resemblance to loaf sugar. Other marbles are *compact*, as the yellow marble of Sienna, several richly coloured marbles of Spain (obtained chiefly from the Pyrenees), and a beautiful black marble with clear white spots, which is quarried in the South of France (Arrière; Aude; Basses Pyrenees).

There are many other sorts, containing an immense number of petrifications. Some of the grey Derbyshire marble consists

almost entirely of portions of encrinites (called there, *screw-stones*) ; a similar kind is found in the neighbourhood of Mons, and extensively used in Paris for tables and other furniture, under the name of *petit granit*. Others are full of the remains of shells, both bivalves and univalves, some of which retain the pearly lustre and brilliant colours of recent shells. The limestone of the South of Devon, (Plymouth marble,) which is much used there for chimney pieces, &c., abounds in fossilized madrepores of a grey colour, prettily veined with red and white.

*Stinkstone* is limestone containing a large proportion of bitumen, which when rubbed or scratched by any hard substance, or slightly heated, gives out a strong fetid odour : it may be observed in some of the black and grey marble of Derbyshire.

*Öölite* or *roestone*, so named from its resemblance to the roe of a fish, forms large beds, extending through a great part of England. The Bath and Portland building stone are good examples of it.

*Peastone* or *pisolite* differs from it only in the larger size of the grains.

*Chalk* is carbonate of lime of an earthy texture. It forms the cliffs along the south-east coast of England, which acquired for our island the name of Albion. The lower stratum is much more compact than the upper chalk, and less white.

*Rockmilk* resembles chalk, but is much more tender : it is found in the clefts of mountains, where it is deposited by water containing calcareous particles.

*Stalactites*\* are sometimes transparent and have the crystalline structure of calcspar, sometimes they consist of parallel layers or bands of different degrees of translucidity or shades of colour ; this sort is often employed for vases and slabs, under the names of *alabaster* and *onyx marble*.

*Calcareous tufa*. In Derbyshire are several springs, called there *petrifying springs*, which quickly incrust any object immersed in them, by depositing on it the lime they hold in solution : this incrustation is *tufa* or *tuff*. But the most remarkable

\* See p. 15.

water of this kind is that of a stream at St. Allyre, near Clermont, in Auvergne, which, having been allowed to run for a length of time in the same channel, formed by degrees an embankment 240 feet long, 12 feet wide, and 16 feet high at the extremity; and near it runs another stream, whose calcareous waters have raised an arch so broad and solid, that carriages pass over it in safety.

Limestone rocks are intersected by veins affording the ores of lead, zinc, and copper, and afford specimens of these intermixed with fluorspar, calcspar, and quartz.

The limestone rocks also contain the most extensive and interesting caverns; they are generally adorned with stalactites which assume the form of obelisks, gothic architecture, groves, wreaths, and draperies; sometimes of dazzling whiteness, sometimes sparkling with innumerable tufts of crystals.

4. ARRAGONITE (Hard carbonate of lime) appears to be the same substance as calcspar, but differs in its greater hardness, which is nearly that of fluorspar; and in its crystallizations, which originate from a rhombic prism. It never forms large masses like the rocks and strata of limestone, but its crystals are found in several situations: very fine ones occur in a red clay near Molina in Arragon, and in Valencia: and a beautiful variety, in the form of a delicate coralline and snow white, is brought from some of the mines of Styria and Bohemia: it was formerly thought to be a carbonate of iron, and called *flos-ferri*.

Several analyses of arragonite indicate a very small quantity of carbonate of strontia and water as constituents: but the proportion being variable and not exceeding 4.7 per cent., it is doubted whether these ought to be regarded as essential to its composition, or accidental.

5. DOLOMITE (Miemite; Bitterspar; Magnesian limestone). This is a combination of the carbonates of lime and magnesia, generally in about equal parts, sometimes with a small portion of carbonate of iron, which, however, does not affect the crystallization. At first sight, the crystals of dolomite might be mistaken for those of calcspar, but they present no other variety

than primary rhombohedrons, sometimes large, transparent, and brilliant; or the same solid, with a single modification on the lateral angles. It affords brilliant cleavages, is a little harder than calcspar, and dissolves with scarcely any perceptible effervescence.

*Pearlspar* or *brownspar* is a crystallized variety, common in England, particularly among the lead and copper ores; it is distinguished by its lustre, and the curvature of the faces: it is sometimes of a golden-yellow colour, but more often brown: translucent or nearly opaque.

*Gurhofian* is white and compact, with the texture of porcelain.

*Granular dolomite* has very much the appearance of white marble; but is more easily crumbled. A great part of Mount St. Gothard, and the mountains of the Tyrol, are of this substance, which produces the finest crystallized specimens.

*Magnesian limestone* is finely granular and generally of a yellowish grey colour. It forms extensive beds in the North of England, and has been selected as a building-stone in the construction of the New Houses of Parliament. The lime obtained by burning this limestone, is said to make excellent mortar.

6. CARBONATE OF MAGNESIA (Giobertite; Magnesite).—This is a scarce substance; found occasionally in serpentine, either in fibrous plates, or small rhombohedral crystals. Hardness 3 to 4.

*Nemalite* is the same, containing water; sometimes in grey silky fibres, sometimes white and earthy, resembling the magnesia of the shops. Both occur at Hoboken, in New Jersey.

7. CARBONATE OF IRON (Ironspar; Spathic iron; Siderose). This mineral also crystallizes in the same system, and presents some of the same forms as calcspar. Beautiful groups of the flat rhomboid, No. 5, p. 8, rounded on the edges so as to have the form of a lens, are obtained in Piedmont, and at Baigorry, in the Pyrenees: hexagonal prisms from St. Agnes, in Cornwall, and other varieties from Cumberland, usually as-



sociated with quartz. They are generally of a yellowish grey, or a rust colour; rarely white. Sometimes it is massive, with a crystalline structure, filling veins, and exactly resembling calcspar in appearance: it may be distinguished, however, from that mineral by greater hardness = 4, higher specific gravity = 3 to 3·8, and by its darkening and becoming magnetic when heated by the blowpipe.

*Clay iron ore*, a mineral extensively used in the English iron foundries, is carbonate of iron rendered impure by an intermixture of clay and silica, oxyde of iron, and other carbonates; it is earthy or compact, generally grey or brown, and occurs in flattened nodules in the coal districts. They very generally contain impressions of fossilized ferns and other plants.

8. CARBONATE OF MANGANESE (Diallagite). Generally of a pale rose colour; cleavable parallel to a rhombohedron rather less obtuse than that of calcspar. Specific gravity 3·2 to 3·6. It is a rare mineral, found occasionally in Saxony and Transylvania. Distinguished from Rhodonite by inferior hardness.

9. CARBONATE OF ZINC (Calamine, Smithsonite) is abundant in many of the localities of lead ores, particularly in England and Carinthia. It is massive, stalactitic, or incrusting, not unfrequently crystalline, and is another example of the prevalence of the rhombohedral system in the *carbonates*; but crystals are small and not frequent, resembling No. 3, p. 7, and No. 8, p. 8.\*

Calamine dissolves with very perceptible effervescence; but is distinguished from calcspar by volatilizing before the blowpipe. It is smelted with other ores of zinc.

\* For the convenience of reference a list is annexed of the obtuse angle of cleavage in the rhombohedral carbonates.

|                       |   |   |   |   |          |
|-----------------------|---|---|---|---|----------|
| Diallagite            | . | . | . | . | 103°     |
| Calcspar              | . | . | . | . | 105° 5'  |
| Dolomite              | . | . | . | . | 106° 15' |
| Carbonate of iron     | . | . | . | . | 107°     |
| Carbonate of magnesia | . | . | . | . | 107° 25' |
| Carbonate of zinc     | . | . | . | . | 107° 40' |



10. **WITHERITE** (Carbonate of Baryta). This mineral is abundant in many of the English lead mines, particularly in those of Alstone Moor, Shropshire, and Anglesark in Lancashire; it is rarely crystallized, but occurs in large masses resembling alum. When powdered and thrown on hot coals, it emits a phosphorescent light; but it is distinguished from most other carbonates and earthy minerals, chiefly by its high specific gravity = 4.29, which, however, has occasioned its being mistaken for a lead ore. Fusible, without addition, to a glassy globule.

The salts of baryta used in chemical analyses, are prepared from witherite, and in the North of England it is used as a poison for rats.

Barytocalcite is a carbonate of baryta and lime, found at Alstone Moor.

11. **STRONTIANITE** (Carbonate of Strontia). A mineral that was first discovered among lead ores at Strontia in Argyleshire, and is still found in some few other localities. It is rarely crystallized, but occurs fibrous and coarse granular, almost constantly of a pale yellow-green colour, and translucent. Specific gravity 3.6. It may be fused by a strong heat, and gives a red colour to the flame, a property which has caused it to be used in pyrotechny.

12. **CARBONATE OF LEAD** (White Lead Ore; Native ceruse; Lead spar). This is the same substance as the white lead of commerce, which is prepared artificially. It is abundant in some lead mines, filling large veins or intermixed with other ores, either compact, earthy, or crystalline. Its crystals are derived from a right rhombic prism,\* differing very little from that of witherite, and are often grouped so as to form a cross or a star. It is the only mineral which equals the diamond in brilliancy; its lustre, when pure and transparent, being ada-

\* Angle of the rhombic prisms which are the primary forms of

|                   |   |   |   |   |          |
|-------------------|---|---|---|---|----------|
| Witherite         | . | . | . | . | 118° 57' |
| Strontianite      | . | . | . | . | 117° 32' |
| Carbonate of lead | . | . | . | . | 117°     |

mantine. It is brittle; and the specific gravity as high as 6.5 to 6.7. When fused by the blowpipe on charcoal, a bead of lead is obtained; or if dissolved in nitric acid, upon immersing a piece of zinc (the surface being quite clean) metallic lead will quickly be precipitated on it in brilliant laminæ. Either of these operations will distinguish it from *witherite*. Some of the finest crystallizations are brought from the lead mines of Lanarkshire. When massive it has sometimes a crystalline structure, splitting readily into large flakes with a brilliant surface. An earthy variety, resembling chalk in its appearance, is common in the lead mines of Durham and Derbyshire. But it is a mineral met with not only in lead mines: it is frequently found with copper pyrites and blende: and in Cornwall, with antimony, and other minerals peculiar to that district. In these situations it often forms columnar masses or acicular crystals, with a silky lustre.

No. 52.



No. 53.



The *sulpho-carbonate* of lead, which is this substance combined with about one third of its weight of sulphate of lead, resembles it in brilliancy and weight, but when dissolved in nitric acid, it leaves a residue which is sulphate of lead.

### CARBONATE OF COPPER.

This term comprises three species, differing in the proportions of their constituents: but they are all soluble in acids, and their solutions will precipitate metallic copper on the blade of a knife, or any piece of clean iron immersed in them.

13. AZURE COPPER ORE is a beautiful mineral of a dark blue colour, inclining to purple, and, when pure, semi-transparent and vitreous; when powdered, a bright azure. It is generally crystallized, in short oblique prisms somewhat modified, which are often grouped into globular and reniform masses; when more slender, in tufts.

The finest specimens are obtained in Hungary, and at Chessy, near Lyons, where it is abundant; it is generally converted into the *sulphate of copper*, an application which is found to be more profitable than smelting it for copper, although it contains above 50 per cent. of the metal.

14. MALACHITE is another beautiful substance: it is rarely crystallized, but occurs in botryoidal and reniform masses, from the size of a nut to a foot or more in diameter, with a smooth surface and a finely fibrous structure. Its colour is a bright pure green; and when broken it exhibits concentric bands of various shades, following the curves of the surface. It is little harder than calcspar, but is much employed for objects of ornament, since, notwithstanding its softness, it receives a fine polish; and when cut, the concentric rings of dark and light green have a very pleasing effect. Hitherto, the large and fine blocks of malachite employed for these purposes have been obtained from Siberia: but it appears probable that the Burra Burra mines in South Australia may soon rival that long celebrated locality; as they have already produced compact masses of great beauty, and crystallized specimens both of this and the blue carbonate. These ores differ in composition, the blue carbonate containing less copper and water, and more carbonic acid, than malachite.

15. A dark brown mineral, without lustre, and sectile, has been found in India, which is said to be *anhydrous carbonate of copper*.

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#### FAMILY IV.—HYDROGENIDES.

##### Genus I. HYDROGEN.

Pure hydrogen is rarely met with in nature; but mixed with sulphuretted hydrogen, it is often disengaged from fissures in the earth, during volcanic eruptions and earthquakes.

##### Genus II. WATER.

A great deal might be said about this most useful substance, which exists in so many forms, and under so many different

circumstances. When perfectly pure, it consists (by weight) of the following matters in combination :

Oxygen . . . . . 88·9

Hydrogen . . . . . 11·1

But all water, whether pure or saline, contains some atmospheric air, without which it would be unfit for the support of either animal or vegetable life. The clearest springs generally contain, also, particles of one or more salts in solution. When the saline matters are in such quantity that the springs derive from them medicinal properties, they are called *mineral waters* : such are the springs of Cheltenham, Leamington, and others. Sea water derives its bitter taste from the salts of magnesia that it contains.

Warm springs are common in several countries ; and some have a very high temperature. The celebrated water of Barèges in the Pyrenees, which is impregnated with sulphureous vapours, varies from 99° to 117° (Fahr.), and the spring of Bagnères de Luchon, of the same kind, raises the thermometer, sometimes, above 140°.

The Geysers, or boiling fountains of Iceland, at a depth of some yards, must be far hotter than boiling water at the surface of the earth, and hold even silica in solution.

Although water is liquid at a moderate temperature, when solidified by cold it crystallizes and assumes the form of hexagonal prisms, and a variety of stellar figures, always having six rays or branches at equal angles : these crystallizations are often perceptible in flakes of snow.

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## FAMILY V.—NITRIDES.

### Genus I. NITROGEN OR AZOTE. ,

This gas is contained in the water of many springs : it is said, that from one of the warm springs of Bath upwards of 200 cubic feet are disengaged daily.

Azote combined with oxygen forms nitric acid : its combinations constitute

## Genus II. NITRATES.

These salts are all soluble in water, and, when thrown on live coal, cause vivid combustion.

1. SALTPETRE (Nitre; Nitrate of potash). On the surface of the soil and on the sides of caverns, chiefly in calcareous countries, and on the walls of old buildings and cellars, this salt is often met with in the form of a thin crust, or tufts of minute crystals. In India, Spain, and Egypt, large quantities are collected from the ground during the hot weather succeeding the periodical rains. In Kentucky, and some other of the United States, it is obtained from the earth that forms the floor of caverns. One of its principal uses is in the fabrication of gunpowder, and it is employed in medicine, and in the preparation of nitric acid.

2. NITRATE OF SODA. This salt is obtained in large quantity in Peru, near the Bay of Yquique, from a bed from two to three feet thick, where it is mixed with glauber salt, sand, and the remains of recent shells; the whole appearing as if it had been covered by the sea at no very distant period. Burns on coal with a strong yellow light.

3. NITRATE OF LIME, and 4. NITRATE OF MAGNESIA, are found dissolved in the water of some springs; the latter characterised by its bitter taste: they are also formed on old walls along with saltpetre.

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## FAMILY VI.—SULPHURIDES.

This family contains a great number of substances that are highly important and useful in the arts of life, particularly most of the ores whence we obtain copper, silver, lead, zinc, and antimony; and they are not less interesting to the mineralogist from the beauty and variety of their crystallizations and colours.

## Genus I. SULPHUR.

NATIVE SULPHUR, when crystallized, is a beautiful mineral: the crystals are transparent, of a bright yellow slightly inclining



to green ; or, when they contain selenium, of a rich orange tint. They are acute octahedrons, sometimes with the summits, sometimes the edges replaced, the base being a rhomb.

The finest specimens are obtained from the mines near Cadiz ; and from the Val di Noto and Val di Mazzara, in Sicily, where groups of brilliant crystals are prettily contrasted with those of celestine, equally brilliant and of a pure white. In both these localities the sulphur is embedded along with gypsum, in the strata which furnish rock salt. But by far the greater part of the sulphur which is employed in different manufactures and chemical preparations, is derived from those great depositories called *Solfatara*, which exist in the immediate neighbourhood of modern volcanos, such as those of Puzzuoli, near Naples, in Sicily, and Guadaloupe. It is said that in 1820 Sicily produced 70,000 tons of sulphur, of which 40,000 were exported to Great Britain alone. Sulphur is collected also from the crater of Vulcano (Lipari) ; and other active volcanos furnish it abundantly. In these deposits the sulphur is massive. in crusts and stalactitic forms, and often opaque.

The uses of sulphur in the manufacture of gunpowder and sulphuric acid are well known : combined with *mercury*, it produces vermilion ; and it is employed in bleaching and in medicine.

## Genus II. SULPHURETS.

1. SULPHURETTED HYDROGEN. Those who have tasted the Harrowgate water are acquainted with one distinguishing character of this gas,—its smell, resembling that of *rotten eggs*. It is dissolved in the water of many other springs both in Europe (Pyrenees) and America (Virginia). It is owing to this gas floating in the atmosphere of all large towns, that silver and copper so soon become tarnished when left exposed to the air ; it unites with the metal, superficially, and forms sulphurets of silver and copper.

2. CINNABAR. This is a sulphuret of mercury, and occurs in various states : sometimes in crystals which are perfectly

transparent, brilliant, and of a fine deep carmine colour : sometimes massive, with a granular structure, the colour inclining to steel grey, and the lustre slightly metallic ; and, occasionally, as a fine powder of a rich scarlet colour (native vermillion), which is contained in the cavities of massive cinnabar. There is also an impure variety, with a slaty structure, of a dark liver-red or blackish colour, which contains, besides earthy matter, carbon, and sometimes bitumen (*hepatic ore*).

The crystals are six-sided prisms, generally modified on alternate edges ; but they are usually very small and complex. The specific gravity of cinnabar, when pure, is 8, which is higher than that of any ore which resembles it. But if a specimen should not be recognised by its external characters, it may be ascertained by the blowpipe : the sulphur will burn away with a pale blue flame and sulphureous smell ; and the whole of the mercury will be volatilized by the heat ; and if a piece of clean copper be held over the vapour of the cinnabar, it will be coated with mercury.

From this ore the greater part of the mercury of commerce is obtained by a process of distillation.

There are in Europe several extensive deposits of cinnabar ; particularly at Almaden, in Spain (Province of La Mancha) ; at Idria, in Carniola ; and at Potzberg, in the Duchy of Deux Ponts, on the Rhine. Those of Idria, discovered in 1497, are very extensive and productive, though the ore, which is principally hepatic cinnabar, is less rich than that of Almaden. Pliny records that from the latter place the Greeks imported red cinnabar 700 years before the Christian era ; and that in his time the Romans received thence, annually, 700,000 lbs. weight. The principal vein under exploration is from 14 to 16 yards in thickness, and appears rather to increase than diminish in width, as it descends into the earth.

In the Idrian mines, a great conflagration took place in 1803, and the volatilized mercury occasioned dreadful diseases among 900 persons in the vicinity. The health of the work-

men employed in the quicksilver mines suffers very much from the poisonous vapours constantly floating in the air they breathe.

Sulphurets of Silver.

3. SILVER GLANCE (Vitreous Silver; Argyrose). This ore, when pure, consists of 86·5 parts of silver, and 13·5 of sulphur, and furnishes the principal part of the silver of commerce, being the most abundant of its ores, and, if we except *native silver*, the richest. It is of a dark steel-grey colour, with metallic lustre, and is found both massive and crystallized in forms belonging to the cubic system (figs. 2, 3, 8, 9), but without any trace of cleavage; and the surface of the crystals is often bluish-black, or iridescent. Its specific gravity is 6·9 to 7·2; higher than that of copper glance, the mineral which it most resembles: it is soft and sectile, so that small chips may be cut off without crumbling.

By exposing it to the blowpipe, a bead of silver is obtained, without the addition of any flux, the sulphur gradually burning away: it is soluble in dilute nitric acid, and if a piece of copper be dipped into the solution, metallic silver will be deposited on its surface. This test applies equally to all silver ores when dissolved in acid.

In the rich silver mines of Saxony and Bohemia, situated in the mountains of the Erzgebirge, this ore forms considerable veins: but those worked in the mines of Mexico and Potosi greatly surpass them in size. The crystals adhere to the sides of cavities, and are accompanied sometimes by calcspar, sometimes by quartz, and often by copper pyrites.

4. BRITTLE SILVER GLANCE (Black Sulphuret of Silver) is a sulphuret of silver containing antimony, which is of a darker colour than the preceding, and when powdered appears quite black. The crystals, which are rare, are hexagonal prisms, sometimes terminated by pyramids, or modified by planes on the terminal edges.

The blowpipe reduces it to a bead of silver; the sulphur burning away and the antimony being volatilized in white

fumes. It occurs principally in the silver mines of Schemnitz in Hungary, and Freyberg in Saxony, where it is wrought and smelted.

5. RED SILVER ORE (Ruby silver; Rubinblende) is of two kinds—the *dark* red silver ore is a sulphuret of silver and antimony, the *light* red silver ore in place of antimony contains arsenic: externally they differ only in depth of tint, both occurring in crystallized masses of a beautiful ruby colour, sometimes so intense as to appear black; the crystals resemble some of the forms which belong to calcspar, and are derived from a similar rhombohedron. The powder of the antimonial ore is dark red; that of the arsenical, scarlet. When exposed to the blowpipe, both kinds afford a bead of silver: the antimony of the one evaporating in white fumes, and the arsenic of the other producing the characteristic smell of garlic. They contain from 59 to 64 per cent. of silver: the brittle silver ore is still richer.

They are all found in several localities of silver glance, though comparatively in small quantity in the European mines: but in some parts of America, particularly Mexico, dark red silver is the principal ore, and the mines of Somberete and Cozala, where that species chiefly is raised, have produced immense quantities of metal.

*Myargyrite* is an antimonial sulphuret, which affords but 36.5 per cent. of silver: externally it is black and semi-metallic, but when powdered appears to be very deep red.

*Polybasite*, which is rich in silver, contains about 9 per cent. of copper and iron: colour, dark steel-grey.

The presence of copper may be detected by dissolving the globule, obtained by fusion, in nitric acid: the copper will be quickly deposited on a knife blade dipped into the solution.

*Stromeyerine*, a sulphuret of silver and copper, has been found at Schlangenberg in Siberia, in small compact masses of an iron-grey colour and metallic lustre. These substances occur in but few of the great depositories of silver ores, and in very small quantity.



### Sulphurets of Copper.

There are several combinations of sulphur with copper, some of which, the copper glance, copper pyrites, and variegated copper, are valuable ores.

6. **COPPER GLANCE** (Vitreous Copper Ore). This is the grey copper ore of the Cornish miners ; it has a dark steel-grey colour, and when freshly broken a perfectly metallic lustre ; but the exterior is often black and dull. Its crystals belong to the rhombohedral system, and are generally short hexagonal prisms, with the terminal edges replaced or terminated by pyramids : and, sometimes, double pyramids occur, without any intervening prism. It is more often, however, found in masses without any regular form, or filling small veins. When not crystallized it might easily be mistaken for the sulphuret of silver, but the fracture has less brilliancy, and the copper ore melts easily before the blowpipe, but is not so quickly reduced without soda. The specific gravity, also, does not exceed 5·8.

This is the richest of all the sulphurets of copper, affording 75 per cent. of metal, and being in general very free from any other. It has been met with in some of the Cornish copper mines, but only in small quantity ; but in the Oural mountains it is an object of extensive exploitation : it is said to occur there in nodules of various sizes, disseminated in veins of clay and gravel.

7. **VARIEGATED COPPER ORE** (Phillipsite). This was long considered to be the same substance as copper pyrites, of which the surface was tarnished ; but it differs from it in containing less iron and sulphur, affording about 60 per cent. of copper, while copper pyrites does not yield more than 33 or 34. The pooriness of the latter, however, is compensated by its greater abundance. Both the crystallized and mammelated varieties usually exhibit brilliant colours, in which purple tints are the most conspicuous : these, however, are superficial, and on breaking it the colour appears to be rather browner than that of metallic copper. Crystals are rare : they are generally



cubes with the angles replaced (Pl. fig. 2); sometimes it forms a thin coating on crystals of copper glance, and it is often disseminated amongst quartz and other minerals. It is softer than copper pyrites, and the colour much redder: and it is less easily fusible than copper glance. Specific gravity about 5.

8. **COPPER PYRITES** (Yellow Copper Ore) is the most abundant of the English copper ores. Its colour is that of brass, and its lustre perfectly metallic and shining, particularly when fresh broken. It is easily scratched by a knife; differing in this character from *iron pyrites*, which is much harder. Groups of small crystals, which are tetrahedrons variously modified, or octahedrons, differing little from the regular one, are often sprinkled over other substances, as quartz, calcspar, fluorspar, galena, and blende; but they are very seldom distinct or perfect.

Copper pyrites, when pure, consists of sulphur 35·87, copper 34·40, and iron 30·47. Both this and the variegated ore, when fused by the blowpipe, afford a globule which is attractable by the magnet.

Copper pyrites forms veins in granite, slate, and other rocks, sometimes filling them entirely, sometimes distributed in irregular masses varying in size, and occasionally weighing some hundreds of pounds. The Derbyshire mines, those of Freyberg in Saxony, and St. Marie aux Mines in Alsace, have produced the most beautiful specimens of this ore.

9. **GREY COPPER ORE** (Fahlore, or Fahlerz). The composition of this ore varies exceedingly in different localities; but it still presents nearly the same appearance; a light grey metallic substance, either massive, or crystallized in the form of the regular tetrahedron, which is generally modified by planes on the edges or angles. It consists principally of sulphuret of copper, antimony, and iron, with arsenic, zinc, or silver, and sometimes with all these metals: the proportion of silver

No. 54.



amounts in some instances to 17 per cent.; the ore is then worked for the sake of the silver as well as of the copper: this is the case in the mines of Chili. Good crystals are sometimes obtained in the Cornish mines.

10. **BELLMETAL ORE** (Tin pyrites). A rare mineral which has been found, hitherto, only in Cornwall: it is metallic, of a yellowish-grey colour, inclining to red, and consists of sulphur 30·5, copper 30, tin 26·5, and iron 12. Does not crystallize; specific gravity 4·3 to 4·78.

11. **TENNANTITE** is a sulphuret of copper and arsenic, which is also peculiar to a few localities in Cornwall. It occurs in small black brilliant crystals, which are rhomboidal dodecahedrons, sometimes with the angles truncated.

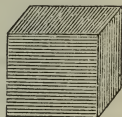
Sulphuret of iron.

Of this there are three species; two of which, *common* and *white iron pyrites*, differ in crystallization, but, like calcspar and arragonite, consist of the same elements and in the same proportions; namely, sulphur 52·70 and iron 47·30: the third species, *magnetic pyrites*, is composed of sulphur 40·15 and iron 59·85. Their specific gravity varies from 4·6 to 5.

12. **COMMON PYRITES** (Martial pyrites; Mundic of the Miners) is a yellow metallic substance, crystallizing in cubes, octahedrons, and more particularly in forms presenting faces of the pentagonal dodecahedron (Pl. figs. 13, 14, 15, 16).

The planes of the cube are very often streaked in directions corresponding to these faces. Independent of its crystallizations, which are generally perfect and often on a large scale, it may be distinguished from copper pyrites by its paler colour, more conchoidal fracture, and greater hardness, scratching glass and striking fire with steel. This latter property of pyrites was known to the ancients, who gave it the name it still bears, which means *fire-stone*. For the same reason, it was used in the early times of fire-arms, instead of the gun-flints by which it was afterwards replaced.

No. 55.



The ancient Peruvians are thought to have used it for mirrors, small polished plates of it having been found in some of their tombs; hence in that country it is still sometimes called, *piedro de los Ineas*. Formerly, when steel buttons were in fashion, pyrites also was cut into such ornaments, and worn under the name of *marcasite*.

At the present time, though it is applied to none of these purposes, it is very useful, being employed in the production of sulphuric acid, alum, and sulphate of iron, or copperas.

Iron pyrites is one of the most abundant ores in nature, and more universally distributed perhaps than any other mineral, being found in every kind of rock that we are acquainted with. In some localities, it contains particles and scales of gold: at Beresof in Siberia, and Macugnaga in Piedmont, the gold occurring in this manner is a principal object of research.

13. WHITE IRON PYRITES, so called from its very pale colour, occurs in groups of thin tabular crystals derived from a rhombic prism, which present a number of very sharp or acute edges: from its peculiar forms it has been called *cockscorn pyrites* and *spear pyrites*.

The radiated nodules so common in the chalk cliffs, are of this kind: their exterior is often of a brown colour, and without any metallic lustre; this is the result of decomposition, by which it is converted into hydrous oxyde of iron; entire crystals have sometimes undergone this change, and are called *hepatic pyrites*. Both kinds are found in coal, and their decomposition occasions the spontaneous combustion that sometimes takes place in coal mines.

Ignorant persons often persuade themselves that the small veins and scales of pyrites in coal, *may be gold*; but gold is malleable and sectile, qualities which do not belong to pyrites.

14. MAGNETIC PYRITES is of a darker colour, inclining to that of bronze, and is much softer than the other species; when crystallized, it assumes the form of the hexagonal prism. It is not a plentiful substance, but has been found in Cornwall, Derbyshire, and several other countries.

15. **ARSENICAL PYRITES** (Mispikel) is nearly as white as silver, and hard enough to give sparks with steel, at the same time emitting a strong odour of arsenic, of which it contains above 40 per cent. It abounds in the tin veins of Cornwall and Bohemia, mostly in crystals, which are rhombic prisms modified on the angles; and sometimes embedded in rocks of granite and micaschist; but rarely in the veins which afford silver and lead. It is sometimes radiated.

16. **ALABANDINE** (Manganblende; Sulphuret of Manganese). In the gold mines of Transylvania, this ore, which is black and metallic, occurs, penetrating or embedded in the rose-coloured manganese. Infusible.

17. **MOLYBDENITE**. This ore, which is a pure sulphuret of molybdenum, occurs in small masses which strongly resemble graphite; but with care they may be separated into thin laminae, which are flexible, but not elastic. Sometimes, but rarely, it is crystallized in hexagonal plates.

It has been found in the granite of Cumberland and the tin veins of Cornwall, as well as the Alps, Norway, &c. It may be distinguished from graphite by dissolving in nitric acid. It was thought, in the first instance, to be a native metal, and received the name molybdenum from its resemblance to lead.

18. **GALENA** (Sulphuret of Lead). This may, in general, be easily recognised by its crystallizations, and its very perfect cleavages, parallel to the faces of a cube, as well as by its pure lead-grey colour.

Its most common forms are figs. 3, 4, Pl.; also perfect cubes and octahedrons, and, less often, cubes having the edges replaced, figs. 8, 12. The surface of the crystals is often dull, but that of the fracture always brilliant; and it is so brittle that cleavages may be obtained by a very slight blow. The same crystalline structure prevails where the galena is massive, sometimes resembling that of statuary marble: more rarely it is fine granular, or compact with scarcely any lustre. Its specific gravity is 7.5 to 7.7. It is easily fused, giving off sulphureous fumes, and affording a globule of lead.

Some galena is combined with sulphuret of silver. When this is in sufficient quantity to render it worth the expense of separating the silver, it is called *argentiferous* galena. This is the case in Cornwall and Devon, where several per cent. of silver are obtained from the lead.

In order to know whether galena contains any silver, dissolve a little in nitric acid, and dip into the solution a piece of copper: the silver, if there be any, will be deposited as a white metallic film on the copper.

There is a singular kind of galena found in Derbyshire, called *slickensides*: it forms a thin coating on the sides of some of the veins, having a polished though not always a flat surface, as if produced by friction. It is said that if this film be scratched it explodes violently; for which reason, the miners, when they discover a mass of slickensides, carefully avoid touching it, till they are at some distance, when one of them strikes it with a nail fastened to a long pole, and quickly runs out of the way.

19. BOURNONITE (Endellion) is a sulphuret of lead, copper, and antimony, the former amounting to 40 per cent. It is found in some mines in Cornwall, Saxony, and the Hartz, in very small crystals, nearly black, which are rectangular prisms much modified.

20. BLENDE (Sulphuret of Zinc; Black Jack of Miners). This, when pure, is of a yellow colour, slightly tinged with green; but it is much oftener dark reddish brown, or garnet red, and contains some portion of sulphuret of iron. It crystallizes in the form of the rhomboidal dodecahedron, and very perfect cleavages may be obtained parallel to the faces both of this solid and of the octahedron. The yellow blende is transparent, the darker varieties more or less translucent. The crystals, both externally and when fractured, have considerable brilliancy, but very little metallic lustre: in specimens that are not cleavable, the fracture is often waxy. Blende contains from 50 to 60 per cent. of zinc, the remainder being sulphur and iron; its specific gravity is 4.16. Some varieties become phosphorescent by slight friction.



*Radiated Blende* is of a dark brown colour; it is said to contain 2 or 3 per cent. of *cadmium*, and occurs in nodules.

Blende is found principally in the same localities as Galena, and often intermixed in the same vein; but its crystals are associated also with the ore of copper, and sometimes of tin. It is used in the fabrication of zinc and brass, though it was formerly thrown aside as worthless. White vitriol also (sulphate of zinc) may be prepared from it by decomposition.

21. **SULPHURET OF NICKEL** (Hair pyrites). A rare substance, which occurs in some veins of the Bohemian and Saxon silver mines, and also in Cornwall, in little tufts of crystals as fine as hairs, which are of a greenish colour and metallic. It is soluble in nitric acid, and the solution becomes violet on the addition of ammonia.

22. **NICKEL GLANCE** (Grey Nickel) is a combination of nickel with sulphur and arsenic, which is found in small masses, compact or lamellar, at Helsingland in Sweden.

23. **SULPHURET OF BISMUTH** (Bismuth glance). This ore also occurs in tufts of slender crystals both in Cornwall and some other of the localities of the nickel pyrites; but it may be distinguished by its greater fusibility, melting even in the flame of a candle; and when fused by the blowpipe on charcoal, it leaves on it a yellow deposit, which is the oxyde of bismuth. It contains 81 per cent. of bismuth.

*Argentiferous bismuth ore* has been found with fluor, at Baden, in a similar form.

24. **NEEDLE ORE** is a sulphuret of bismuth, lead, and copper, of a lead-grey colour and metallic lustre. It occurs penetrating quartz and other earthy matters, in the mines of Ekaterinenburg in Siberia, and likewise in the silver mines of Bohemia, Saxony, &c.

25. **SULPHURET OF ANTIMONY** (Grey Antimony). From this ore all the antimony of commerce is obtained. Its lustre is shining and perfectly metallic, and it occurs either massive or crystallized in rhombic or six-sided prisms, generally terminated by four planes. It is seldom that more than one

termination is visible, the crystals being aggregated in divergent groups: sometimes they are several inches in length: very often acicular, and even capillary, intersecting each other in all directions: one variety, (plumose antimony,) consisting of delicate fibres interlaced, resembles *felt*. The surface of the crystals is sometimes tarnished with brilliant prismatic colours; otherwise its colour is lead-grey. It is soft and very tender, yielding to the pressure of the nail; specific gravity 4·3 to 4·6. Cleavable in one direction with ease, and affording thin laminæ, which are flexible.

This mineral is fusible in the flame of a candle, and when exposed to the blowpipe it is entirely volatilized in white fumes. It contains from 73 to 75 per cent. of antimony, the remainder being sulphur. It is distributed through most countries of Europe, but there are few in which it is very abundant: the most extensive mines are those of Hungary and the central part of France: it is met with also in Cornwall, and has been brought from Borneo.

Antimony is applied to many purposes: one most important use is in the composition of *type metal*, for which it is alloyed with lead; and in forming *pewter* and *Britannia Metal*, it is combined with tin. Several medicines also are preparations of antimony.

26. HAIDINGERITE (Berthierite). A sulphuret of antimony containing 15 per cent. of iron and 52 of antimony, which occurs in considerable quantity at Chazelle, in Auvergne, in masses with a confused lamellar structure. It resembles grey antimony ore in its appearance, but by exposure to the blowpipe affords a globule which is attractable by the magnet.

It has been worked as an ore of antimony, but abandoned in consequence of the difficulty experienced in separating the iron.

27 and 28. ZINKENITE and JAMESONITE are Sulphurets of antimony with lead. Both have a steel-grey colour; the former, from Wolfsberg, in the Hartz, crystallized in hexagonal prisms, or fibrous; the latter occurring in small rhombic prisms, or fibrous, in Cornwall and Hungary.

*Geocronite*, *Plagionite*, and *Boulangerite* are all sulphurets of antimony and lead, differing only in their proportions.

*Kobellite* is a radiated ore consisting of the sulphurets of antimony, lead, and bismuth, from Hvena, in Sweden.

29. SULPHURET OF COBALT (Cobalt Pyrites) is a metallic mineral of a light grey colour, breaking with a fine granular fracture, which has been found massive, and, more rarely, crystallized in octahedrons, at Ryddarhytten, in Sweden. Composed of 43 per cent. of cobalt, 41 of sulphur, and a small quantity of copper and iron.

30. COBALT GLANCE (Cobaltine; Silver White Cobalt). This ore occurs in small distinct crystals, which are white with a faint tinge of red, a perfectly metallic lustre, and considerable brilliancy. It crystallizes in the same forms as iron pyrites, particularly figs. 13, 14, 15. Cobalt glance, however, may be distinguished by its colour and greater specific gravity, = 6.29, and being more brittle. It consists of cobalt 33, sulphur 20, arsenic 43, iron 2.

On heating it by the blowpipe, it gives off arsenical fumes, which is not the case with the above-named ore: but both substances communicate an intense blue to borax or any other flux; this result is characteristic of all the ores of cobalt. It may further be distinguished from iron pyrites and arsenical pyrites, by giving a rose-coloured solution in nitric acid.

Cobalt glance is found in greater quantity in Norway and Sweden than in any other country, and is there intermixed with copper pyrites. From this ore is prepared a great part of the smalt and other cobalt blues used in the potteries and for other kinds of painting. It is first converted into a silicated oxyde, called Zaffre, by calcining the ore, in order to volatilize both the sulphur and arsenic, and then heating it with about twice its weight of flint reduced to a fine powder. In this state it is brought to England, where smalt is prepared from it, by remelting the Zaffre with a proper quantity of glass, or glass and potash: this compound, while in a state of fusion, is poured into cold water, which causes it to break into small

angular pieces, like gravel; this is ground, washed, and separated into smalt of different degrees of fineness. Besides its use in painting on porcelain and with oil, a great deal of this colour is consumed in giving a blue tinge to paper, muslin, calico, &c.

Sulphuret of arsenic.

This is of two kinds: Realgar, containing 69 per cent. of arsenic, and Orpiment, which contains only 62 per cent.

31. REALGAR (Red orpiment) occurs in small granular masses and crystals of a fine crimson red colour, which are transparent or translucent, perfectly vitreous and without metallic lustre. The crystals are derived from an oblique rhombic prism and are often complex. It is so soft as to yield to the nail, and is brittle. Specific gravity 3·3 to 3·6.

Realgar is wholly volatilized by the blowpipe, a circumstance in which it differs from the red silver ores; while the arsenical fumes produced by the operation distinguish it from cinnabar: it differs from cinnabar likewise in colour; for when pulverized it appears orange-red, while cinnabar is of pure crimson.

Realgar is found most abundantly in the silver mines of Hungaria, Bohemia, and the Hartz; sometimes with native arsenic: and it is met with in smaller quantity in the craters of volcanoes and the solfataras in their vicinity, where it is often intermixed with the following species.

32. ORPIMENT. This is very different in appearance from realgar: it is very rarely crystallized, but generally in lamellar masses of a brilliant lemon or golden colour: the laminæ are easily separated, and have somewhat of the pearly lustre of talc. The texture is sometimes compact or earthy. Its hardness, specific gravity, and chemical characters are nearly the same as those of realgar. The finest specimens of orpiment come from Persia, and require no other preparation than grinding, to be used as a pigment; it is also prepared in Saxony, artificially; but this has not so fine a colour as the native orpiment. Realgar also is sometimes used in painting, but unfortunately it is not a permanent colour.

## Genus III. OXYDES OF SULPHUR.

1. SULPHURIC ACID (Oil of Vitriol).

2. SULPHUROUS ACID.

These are both produced by the combustion of sulphur in volcanic regions. They escape from the earth in the form of vapour, which is quickly absorbed by the pools and streams in the vicinity, and thus produce the acidulous waters which are sometimes found in subterranean cavities, such as the Grotto of Santa Fiora, in Tuscany, and the caverns of the Isle of Milo.

Sulphurous acid is recognised by its suffocating odour, resembling burning sulphur: the same effect will be perceived from sulphuric acid by immersing charcoal in it and heating it.

The composition of sulphurous acid is sulphur 50·14, oxygen 49·86; of sulphuric acid, sulphur 40·14, and oxygen 59·86.

## Genus IV. SULPHATES.

These salts, with very few exceptions, are transparent, crystalline substances, and the greater part of them are soluble in water.

1. ALUM. The alum of commerce is a well-known substance which may be obtained crystallized in octahedrons, either simple or with the angles, and less often the edges, replaced: but in nature crystallized alum is rare. It occurs most frequently as an efflorescence, or in silky fibrous masses. At Whitby, in Yorkshire, and near Paisley, the slate rocks are quarried for the purpose of obtaining the alum from them; this is done likewise in France, Germany, and other countries.

The common alum of the shops consists of sulphate of alumina, sulphate of potash, and water; but native alum contains, more frequently, *iron* instead of potash, and has somewhat of the inky taste of the pure sulphate of iron: this kind is sometimes called *feather alum* or *plumose alum*, from its form: it is generally of a yellowish colour. There is also *feather alum*, which contains no other salt than the sulphate of alumina.



*Soda alum* has been observed in the Isle of Milo and in South America.

*Magnesia alum* likewise occurs in the latter country, in considerable masses, fibrous and silky.

*Ammonia alum* is found in Bohemia.

2. ALUMSTONE (Aluminite; Alumite). This mineral differs a good deal from alum, being insoluble in water, and nearly as hard as felspar. It exists in large masses in Hungary, at Tolfa (near Rome), and in some other localities, generally compact, and with groups of small crystals in the cavities. These are obtuse rhombohedrons, transparent, or nearly so; and colourless, greyish, or reddish.

It may be dissolved in sulphuric acid: some varieties contain a good deal of silica; and that in Hungary is so hard as to be used for millstones. But its chief use is in the production of alum, which is obtained by calcining, and then exposing it to the air, moistening it frequently with water. Alumstone contains less acid than alum.

*Websterite*, a white, earthy, insoluble substance, is another sulphate of alumina, which has been found at Newhaven in Sussex, and Halle in Saxony. Distinguished from chalk by not effervescing with acid.

3. EPSOM SALT (Epsomite; Sulphate of Magnesia; Sel d'Angleterre; Sel de Sedlitz). Few persons are unacquainted with the strong bitter taste of this salt, which imparts the same quality to sea water. It is most abundant in the water of some springs, and received two of its names from one long celebrated at Epsom in Surrey, and another at Sedlitz in Bohemia.

It occurs also, as an efflorescence, on some voluminous schists of Savoy, and in the earth of numerous caves in the Western States of North America. In the famous mammoth cave of Kentucky, it adheres to the roof in loose masses as white as snow.

4. CELESTINE (Strontian Spar) is the sulphate of Strontia. It is generally crystallized or lamellar, rarely granular or com-

pect. The primary form is a right rhombic prism, obtuse angle  $104^{\circ} 30'$ ; but the larger faces of most crystals are secondary. It is transparent or translucent; sometimes colourless, but more frequently a very pale blue, whence it received the name of celestine; and occasionally flesh red. In its appearance it resembles some of the zeolites, but may be distinguished by inferior hardness, and higher specific gravity =  $3.9$  or  $4$ , and by tinging the flame red when fused by the blowpipe. Composition, sulphuric acid  $43.64$ , strontia  $56.36$ .

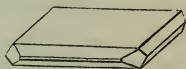
No. 56.



The finest crystallized specimens are brought from Sicily, where it occurs in brilliant divergent groups, with sulphur: it is not common in Great Britain, but nodules are found in cavities in basalt and amygdaloidal rocks, as at Calton Hill, near Edinburgh; and in red clay near Bristol; most of these are lamellar, but some, fibrous or compact.

5. HEAVYSPAR (Barytine; Sulphate of baryta). This is a more abundant mineral than the preceding: the crystals are most commonly tabular, presenting numerous modifications, and often of a very large size: they are derived from a prism differing very little from that of celestine. It is either colourless or, from an intermixture of ochry clay, brownish yellow or red; sometimes also grey, and even black. Fibrous varieties are often dark brown and opaque; when earthy it is white and opaque, resembling chalk. The specific gravity of heavy spar is  $4.7$ ; hardness generally above that of calcspar.

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If sulphate of baryta, after being calcined, be exposed to the sun's rays, and then taken into a dark room, it emits a reddish phosphorescent light; this property was first observed in some radiated groups of crystals from Bologna, whence that variety received the name of *Bologna spar*: and the calcined substance, powdered and made into small blocks with gum water, was sold under the name of *Bologna phosphorus*.

Fine crystallized specimens are obtained from the Cumberland lead mines, and the mines of Saxony and the Hartz; also from the fuller's earth pits in Surrey.

*Hepatite* is a variety found in the silver mines of Konigsberg, which, when rubbed or heated, emits a foetid smell.

*Cawk* is a name given by the Derbyshire miners to the massive, white, earthy kind.

Heavyspar is used to adulterate the white lead used in painting; and for the preparation of barytic salts for chemical experiments.

Sulphate of Lime.

Of this there are two species: the one containing water; the other, anhydrous.

6. GYPSUM (Selenite; Plasterstone; Alabaster). This species presents considerable variety in its appearance, but its essential characters are generally the same. Its crystallizations are derived from a right rhomboidal prism: specific gravity 2.32: hardness not exceeding 2, and most varieties yield to the pressure of the nail: before the blowpipe, the most transparent crystals immediately become opaque, exfoliate, and are easily crumbled: and all varieties after being calcined, when reduced to powder and mixed with water, harden in drying into a solid mass.

*Selenite*\* is crystallized gypsum; the crystals are generally tabular with bevelled edges; sometimes macled, forming what is called the *arrowhead* crystal: these are often very large and of a deep brownish yellow; otherwise, selenite is generally colourless, transparent, and of a pearly lustre, somewhat resembling stilbite at first sight: but they are easily distinguished by the great difference of their hardness.

Selenite may be cleaved with great

No. 58.



\* *Selene*, Gr., the name of the moon.

ease, parallel to the broader faces of the crystals, and affords thin plates as transparent as glass: the Romans are said to have covered their greenhouses with laminae of selenite, before the art of glass-making was understood; and imported it for this purpose from the Isle of Cyprus, Spain, and even Africa. Fine groups of transparent crystals are brought from the valley of Bex, in Switzerland.

*Alabaster.* We have already spoken of a *carbonate* of lime which is sometimes so named;\* but the term is now more generally applied to the granular variety of gypsum.

The ancients gave the name *alabastron* originally to small vessels of white stone and peculiar form, that were manufactured at the town of Alabastron, in Egypt; but afterwards the term was applied to others of a similar form, or that were applied to a similar purpose, such as holding ointments or perfumes.†

The modern alabaster is the substance so extensively used for carving small statues, groups of figures and animals; and boxes and vases, which are turned in a lathe: for these purposes it is admirably adapted by its brilliant whiteness, translucency, and softness. The best, in point of whiteness and evenness of texture, is quarried near Volterra, in Tuscany. Granular gypsum forms considerable beds in several countries, often associated with beds of rock salt, as in Cheshire; and is frequently tinged and veined with red or grey. This sort is extensively quarried at Chellaston, near Nottingham, and is burnt for *plaster of Paris*. The gypsum of Montmartre, near Paris, contains 7 or 8 per cent. of carbonate of lime, and is used generally for plaster in the construction of buildings, which is said to be superior to any other: the masses of crystalline gypsum which are found embedded in it, are prepared as fine plaster for modellers.

\* See p. 83.

† In the Gospel of St. Luke, chap. vii. v. 37, we find mention of this: "And, behold, a woman of the city . . . . . brought an alabaster box of ointment."

*Fibrous gypsum* is sometimes called satin spar; but it differs from the carbonate of lime so named, not only in much greater softness; it is more translucent, and the slender columns of which it consists are generally very straight.

The analyses of gypsum show it to contain, when pure, sulphuric acid 46, lime 33, water 21.

7. ANHYDROUS GYPSUM (Muriacite; Vulpinite; Bardiglione; Cubespar; Anhydrite). This species is much harder than the preceding, scratching calcspar with ease. The granular kind, which is nearly compact, has much the appearance of marble, but is more translucent, and is cut into slabs for the same purposes, under the names of Marmo di Bardiglio and Vulpinite, from the names of the places where it is quarried.

*Muriacite* is a name given to the crystallized varieties, because they were sometimes found to contain traces of salt (muriate of soda). The crystals are rectangular prisms, generally modified by several planes on the edges, and yield readily to cleavage. Specific gravity 2·5 to 2·9.

8. GLAUBERITE. Small crystals of this substance are disseminated in the rock salt and saliferous clay of Villa Rubia in Toledo: they are very oblique prisms, rather flat, with sharp edges. Glauberite consists of 51 per cent. of glauber salt, and 49 of sulphate of lime, and is partly soluble, the sulphate of lime forming a sediment.

*Polyhallite*,\* so named from the numerous salts it was found to contain, is of a brick-red colour, and coarsely fibrous, with a bitter taste: it consists of the sulphates of lime, potash, and magnesia, and occurs at Ischel in Austria.

9. GLAUBER SALT (Sulphate of Soda). This is found as an efflorescence in some parts of Austria and Tyrol, and around some lakes in Siberia, in the water of which it is dissolved. It has a bitter taste, producing at the same time a sensation of coolness in the mouth. It consists of sulphate of soda 79·8 and water 20·2.

\* *Polus* many, and *halos* salt.



*Thenardite* is an anhydrous sulphate of soda, obtained from Espartines, near Madrid.

10. SAL POLYCREST (Sulphate of Potash). A soluble salt of rare occurrence, which sometimes forms a thin crust on lava; taste, bitter and saline.

11. MASCAGNINE (Sulphate of Ammonia) is characterised by a pungent, bitter taste. It occurs in the form of a mealy coating, generally of a yellow colour, on the recent lavas of Etna and Vesuvius. When dissolved, the smell of ammonia is perceptible.

12. SULPHATE OF IRON (Green Copperas; Green Vitriol; Melanterite). This salt, which is of a sea-green colour, occurs in most localities where iron pyrites is abundant, particularly the *white* pyrites; and is often dissolved in subterranean pools and streams of water. When crystallized, it takes the form of oblique rhombic prisms.

It may generally be recognised by its inky taste, and by producing a black colour if a drop of tincture of nut-galls be added to a solution of it, or even a drop of strong tea; or, by adding a drop of prussiate of potash, a bright blue will be obtained, which is prussian blue. It contains 45 per cent. of water.

*Coquimbite* is another sulphate of iron, which is found in great abundance in South America: near Copiapo, in Chili, it occurs in beds and veins; and in Bolivia it forms part of a hill. It is colourless, brown, yellow, red, or blue, and has a granular or crystalline structure.

There are some other sulphates of iron, differing somewhat in their composition from these, but all soluble, and affording the same results with the tests above mentioned.

13. SULPHATE OF COPPER (Cyanose; Blue vitriol). Like the other soluble metallic salts, this is rarely found crystallized; but is abundant in some localities, dissolved in water. The Parys copper mine in Anglesea, was discovered in consequence of the water being so strongly impregnated with this salt. Both here and at Wicklow, the copper is obtained by immers-

ing bars or any thin pieces of iron in the liquid : after some months, when taken up, they appear to be converted into copper ; the iron being in great part dissolved, and replaced by a deposition of metallic copper. When crystallized artificially it has a fine blue colour, is semi-transparent, vitreous, and very brittle.

*Brochantite* is a sulphate of copper, of a bluish-green colour, insoluble in water, which has been found in Siberia.

14. **SULPHATE OF ZINC** (White vitriol ; Rockbutter). A white soluble salt which is produced by the decomposition of blende, and principally in those parts of mines which have been abandoned. Its taste is nauseous and styptic. When dissolved in water, if a small quantity of potash be added, a white gelatinous precipitate takes place. It is a substance much used in dyeing and in medicine, but is prepared artificially.

15. **SULPHATE OF COBALT** (Cobalt vitriol ; Red vitriol). A soluble salt, distinguished by its red colour. It arises from natural decomposition of the sulphurets of cobalt, and is sometimes found to be dissolved in the water in mines where it occurs : this may be detected by adding any alkali to the solution, when the liquid will become blue.

16. **SULPHATE OF LEAD** (Anglesite). The crystals of this mineral are generally rectangular octahedrons, variously modified, and cleavable parallel to the faces of a prism, very nearly the same as that of celestine. In its specific gravity, which is 6.2 to 6.3, and in its general appearance, it resembles the carbonate of lead, but is rather softer and less brilliant, and may always be distinguished from it by not effervescing with any acid.

Sulphate of lead was first discovered in Anglesea, on cellular quartz : the best specimens are now obtained from Leadhills in Scotland, Baden, and Siberia.

*Cupreous sulphate of lead* of a light blue colour has been found in small quantity at Leadhills : it is coloured by the copper it contains.

17. **SULPHATE OF URANIUM**. At Joachimsthal, in Bohemia,

an earthy yellow substance has been observed, soluble in acids, and giving off water by calcination, which is the sulphate of uranium.

In the same locality, a green sulphate occurs, which contains copper as well as uranium, and is soluble in water.

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## FAMILY VI.—CHLORIDES.

### Genus I. CHLORURETS.

1. MURIATIC or HYDROCHLORIC ACID is a compound of chlorine with hydrogen. It is often disengaged by volcanoes during eruptions, and particularly by Vesuvius, where it is produced in such abundance that, uniting with aqueous vapour, and becoming condensed, it forms pools and rivulets of liquid acid. It has a strong and pungent odour.

2. ROCK SALT (Common Salt; *erroneously*, Muriate of Soda). This important substance is very abundant in nature. It has a perfectly crystalline structure, and may be easily separated by cleavage into cubes. It occurs also in groups of cubic crystals, which are seldom modified: it is rarely fibrous. Transparent salt is generally colourless; but it sometimes has a tinge of blue, violet, or rose colour. When stained by the intermixture of the clay which often lies above it, it has a dirty red colour. It consists of chlorine and sodium.

Extensive beds of salt exist in many countries, particularly Poland and Hungary. The mine of Wielitzka, near Cracow, has been worked ever since 1251. There are three distinct beds of salt, of which the uppermost is 200 feet below the surface; and the lower one about 800. The salt is extracted chiefly from the lower bed, which is much purer than the others. The excavations extend over a distance nearly two leagues and a half in length; and consist of galleries and chambers of immense height, their roof supported by pillars of salt left for that purpose. There are also three chapels in various parts of the mine, where, on certain days, mass is performed; all the altars, statues, and other ornaments being carved in salt.

Salt, in some countries, forms considerable hills above the surface of the ground, as in Spain, where the town of Cardona stands at the foot of a rock of salt above 300 feet high. It is quarried out in the manner of building-stone, and is so pure that it requires only to be crushed to powder. In Moldavia, Persia, Affghanistan, and the North of Africa there are similar hills, which appear to be generally on the borders of extensive desert plains.

The springs which issue from saline strata afford, in many countries, large quantities of salt, as at Droitwich, in Cheshire; Dieuze and Chateau Salins, in France; Schönbeck, in Magdeburg, &c. The greater part of the salt made in the United States is obtained in this manner.

Salt lakes also are numerous in several parts of the world; and the earth around them is generally impregnated with salt, which in the dry season appears on the surface in the form of an efflorescence.

3. SAL AMMONIAC (Salmiac). A soluble salt characterised by its sharp saline taste: it occurs in volcanic regions, in the form of a whitish crust or efflorescence; sometimes, but rarely, crystallized in octahedrons. It consists of chlorine and ammonia, and before the blowpipe is entirely volatilized.

4. SYLVINE, the chloride of potassium, has been observed in the salt mines of Salzburg.

5 and 6. CHLORURET OF CALCIUM and OF MAGNESIUM exist in the water of the seas and of salt lakes, with common salt.

7. HORN MERCURY (Chloruret of Mercury). This is the same substance as *calomel*, and occurs in small quantity in some quicksilver mines, either in small mammellated masses, or modified square prisms, which are transparent, with an adamantine lustre. It is soft and waxy in its texture: specific gravity 6.5; and before the blowpipe is entirely volatilized.

HORN SILVER (Corneous Silver Ore; Kerargyre). This mineral is very similar in appearance to the last species; but the crystals, which are extremely rare, are cubes, either simple

or with the angles truncated. It forms small irregular masses of a grey or brownish colour, or occurs as a thin crust on other ores. It is translucent, soft, and sectile, with a specific gravity of about 5.

In the European silver mines it is rarely met with; but in some parts of Mexico and Peru it forms a large portion of the ores called *pacos* and *colorados*, in which it is mixed with earthy oxyde of iron, and penetrated by numerous fine threads of metallic silver.

9. CERACITE (Chloruret of Lead; *erroneously*, Muriate of Lead). A scarce mineral, first discovered in the Mendip hills; white or yellowish, nearly opaque and somewhat pearly; specific gravity 7.

10. CORNEOUS LEAD ORE (Chloro-carbonate of Lead). A transparent mineral, crystallizing in square prisms, with adamantine lustre, which has been found near Matlock and in Germany. Both this and the preceding species are rare; reducible with soda by the blowpipe.

11. ATACAMITE (Chloruret of Copper). In the desert of Atacama, between Chili and Peru, this substance is found in the form of a dark green sand: the grains are crystallized more or less perfectly in rhombic prisms; and some are very brilliant and transparent. In Chili it is ground up and sold as sand for letters, under the name of *arsenillo*. More recently it has been found in Saxony, massive.

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#### FAMILY VII.—IODIDES.

Iodine, which is a simple substance or element, is not found uncombined. When obtained by art, it appears in the form of black shining particles resembling plumbago, which, when heated in a closed tube, volatilize and become an amethyst-coloured vapour.

Iodine exists in combination with potassium and sodium, in the water of some mineral springs, as at Ashby-de-la-Zouch.

Iodide of Mercury, of a brownish-red colour, has been observed with some other Mexican ores. When prepared artifi-



cially, and free from all impurity, it forms a red pigment, far more brilliant than the common vermilion, but less permanent.

Iodide of silver, also, has been brought from Mexico; of a yellowish-white colour, and lamellar.

Iodide of zinc, from Silesia.

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#### FAMILY VIII.—BROMIDES.

Bromine, which, when obtained alone, is a dark brown liquid, is contained in some mineral springs, and in the water of the lake Asphaltites.

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#### FAMILY IX.—FLUORIDES.

The combinations of fluorine are few in number, and, excepting fluat of lime, are rare substances.

1. FLUORSPAR (Fluat of lime; Fluoride of Calcium; Fluorite; Fluorine; Derbyshire spar). This mineral is widely distributed in nature, and offers considerable variety and beauty in its appearance.

Its colours are generally bright; the crystallized fluor of Durham and Yorkshire is most frequently violet with a tinge of pale green, and perfectly transparent: in Derbyshire, specimens have been raised of a fine clear topaz yellow, and also colourless, often enclosing minute particles of copper pyrites, a mineral which is very often found with it: the radiated fluor from the same neighbourhood is generally amethyst, or deep indigo blue. In Cornwall, and likewise in Saxony, fluorspar of a bright green colour is often the chief veinstone of the copper ores: it is seldom light blue or rose-coloured.

Fluor is crystallized most commonly in cubes, either simple, or with the edges bevelled, or with a very low pyramid on each face (figs. 1 and 12). Its cleavages, however, are parallel to the faces of the regular octahedron, which must, therefore, be regarded as its primary form, though octahedral crystals rarely occur.

The specific gravity of fluorspar is 3·1 or 3·2; hardness 4,

scratching calcspar with ease. When moderately heated, it becomes phosphorescent; some varieties shining with a purple, others with a blue, yellowish, or green light. *Chlorophane* is a name given to a kind that, when heated, exhibits a brilliant green colour; this variety is found in Saxony.

Fluorspar may be dissolved in sulphuric acid; by this process, the fluorine is disengaged; a gaseous acid which has the power of corroding glass, and even siliceous stones.

Massive fluor with a coarsely fibrous or columnar structure, is abundant in Derbyshire; this is the kind chiefly used for making vases and other ornamental objects: it is generally turned in a lathe; but great care is requisite, on account of its brittleness.

The colours of this are sometimes rendered more brilliant by heating the fluor. It has so much resemblance both in colour and structure to some varieties of amethyst, that these vases have often been sold under the denomination, *root of amethyst*: and it is conjectured that the celebrated Murrhine vases of antiquity were formed of the same substance.

*Blue John* is a name given by the Derbyshire miners to massive fluor of an intense blue, which becomes violet when moderately heated.

2. CRYOLITE. This mineral, which has hitherto been found in Greenland, is generally of a pure white colour, translucent, and cleavable into rectangular prisms: it is characterised by melting in the flame of a candle.\* It is a fluuate of alumina and soda.

3. FLUATE OF CERIUM (Flucerine). A rare mineral which occurs at Brodbo in Sweden, in small irregular masses of a pale violet colour, opaque, and with very little lustre. Consists of Fluoric acid and Cerium.

*Basicerine*, which contains a larger proportion of cerium, is of a yellowish colour and crystalline structure.

4. YTTROCERITE is another combination of cerium and fluoric acid with yttria and lime: its colour is grey, reddish, or violet;

\* Its name is derived from *kruos*, ice, in allusion to this property.

texture compact; scratches fluorspar. This also occurs only in Sweden.

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#### FAMILY X.—SELENIDES.

Selenium, which resembles sulphur in some of its properties, is found in combination with a very small number of metals: they all have a metallic lustre; and are characterised by emitting, when heated, a strong smell of hore-radish.

*Clausthalite*, the seleniuret of lead, is very much like galena: it occurs at Clausthal, in the Hartz.

A variety, of a yellowish colour, contains also copper.

*Eukairite*, composed of selenium, silver, and copper, is found disseminated in the calcareous rocks of Smoland, in Sweden.

*Seleniuret of silver* and *of zinc* are said to have been found in very small quantity in Mexico. All these minerals are very rare.

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#### FAMILY XI.—TELLURIDES.

Tellurium occurs in the native state, and alloyed with other metals.

NATIVE TELLURIUM has a lamellar or granular structure and metallic lustre. It is white or very pale grey, and is said to be sometimes crystallized in hexagonal prisms. It is easily fused, and volatilized by the blowpipe, and differs from arsenic and selenium in emitting no odour when heated. When pure, its specific gravity is 6.1, but it often contains a small quantity of other metals.

Tellurium is found chiefly in Transylvania, where also most of its combinations occur, in little veins dispersed through the earthy depositories of galena, red silver ore, gold, &c.

#### TELLURURETS.

1. GRAPHIC TELLURIUM (Graphic Gold; Sylvan). The crystals of this alloy, when perfect, are prisms of four or six sides, modified by smaller planes; but they are always small, often acicular, and grouped together so as to present a resemblance to some oriental written characters.

It is obtained at Nag-y-ag and at Offenbanya, where it is worked as an ore of gold, of which it contains 30 per cent., with 10 of silver, and 60 of tellurium. When fused by the blow-pipe, the tellurium is volatilized, and a small globule of a pale yellow colour remains, which is a mixture of gold and silver.

2. **TELLURIC SILVER** (White Tellurium; Mullerine). This likewise contains both gold and silver; of the former 26 per cent.; but they are combined with lead as well as tellurium: crystals, which are very rare, are modified rectangular laminæ.

This, like the preceding Graphic species, is sought for as a gold ore.

3. **TELLURURET OF LEAD** (Black Tellurium; Elasmose) occurs in small lamellar crystals heaped confusedly together: it is of a dark grey colour, and is often accompanied by the rose manganese of Nag-y-ag.

It contains a few per cent. of gold.

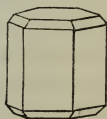
## FAMILY XII.—PHOSPHORIDES.

The natural combinations of phosphorus are phosphates: the phosphoric acid is found combined with several of the earths, and the oxydes of some other metals.

### PHOSPHATES.

1. **APATITE** (Phosphate of lime; Phosphorite). This mineral so strongly resembles, in its appearance, several others, that it received its name from the Greek word *apatao*, I deceive. It crystallizes in hexagonal prisms, which are sometimes modified on the edges or the angles, or on both. The crystals are vitreous, transparent or translucent, and sometimes very bright: those which are of a bluish or green colour might easily be mistaken, at first sight, for beryls: some are colourless, violet, or lilac, and, if not distinctly crystallized, appear extremely like fluorspar. Apatite, however, is harder than fluorspar, and is not cleavable, but breaks with a conchoidal fracture: on the other hand, it is

No. 58.



less hard than beryl, being No. 5 in the scale of hardness, and heavier; specific gravity 3.1: it is soluble in nitric acid; and becomes phosphorescent when heated.

*Asparagus stone* is apatite of a greenish yellow colour, from Tyrol, where the crystals are embedded in talc.

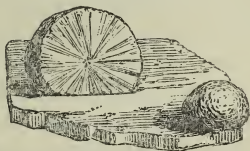
*Moroxite* is a name given to bluish-green crystals from Arendahl, in Norway.

*Phosphorite* is opaque, and white or yellowish white: when broken it shows a sort of feathery structure, and numerous small cavities. This variety is massive, and at Logrosso, in Estramadura, forms entire hills; it is there used as a building stone. In Hungary, phosphorite occurs of a loose earthy texture.

Apatite is a scarce mineral in England: small crystals have been found in decomposing granite near St. Austle, in Cornwall; and fine groups of a larger size, with tourmalines, near Chudleigh, Devonshire. Fine specimens are obtained from the metalliferous veins of Bohemia, Moravia, and Saxony, and from the rocks of St. Gothard.

2. WAVELLITE (Hydrargillite) occurs in small globular or semi-globular masses, seldom exceeding half or three quarters of an inch in width, attached to the surface of slate and other rocks. They consist of minute crystals diverging from a centre, and when broken exhibit this radiated structure and a bright glassy lustre. The colour is most frequently greyish or greenish white, but it has been found in Scotland of a dark green colour.

No. 59.



Wavellite is a phosphate of alumina combined with water and a very small quantity of the fluuate of alumina. It was first discovered near Barnstaple, in Devonshire, by Dr. Wavel, and it occurs in a similar situation at Dumbarton, and near Cork. It is found also at Freiberg in Saxony, in Bavaria, and at several places in the United States.



3. **BLUESPAR** (Azurite; Klaprothine). This mineral has been confounded with lapis lazuli, but the blue colour inclines less to purple; its specific gravity is 3, and it is infusible, losing its colour, however, before the blowpipe. It is a phosphate of alumina and magnesia, and is found principally in Styria, embedded in micaceous and quartz rocks.

The *Turquoise*, to which fashion has attached so high a value, appears to be nearly the same substance in composition as bluespar, except that it contains a very small quantity of copper, to which it owes its greenish blue colour. It occurs in small reniform masses, embedded in veins which traverse a mountainous district of Khorassan, near Nishapur and Firozkuh; also in rolled pebbles.\*

4. **WAGNERITE**, a fluo-phosphate of magnesia, occurs at Salzburg, in yellowish or greyish white oblique prisms: about as hard as apatite: rare.

Phosphates of Iron.

5. **VIVIANITE**. When crystallized it is perfectly transparent, vitreous, or somewhat pearly, and of a deep blue colour.

The crystals are oblique prisms, variously modified, and easily cleavable in one direction, parallel to their axis. It is tender, and scratched with ease by calcspar; specific gravity 2·66. It sometimes forms radiated nodules, and occurs also in opaque earthy masses, resembling lumps of common indigo.

Vivianite consists of phosphoric acid 31·18, protoxyde of iron 41·23, and water 27·49. When pulverized, it may be fused into a scoria attractable by the magnet.

This mineral was first discovered in Cornwall, and has since been found at Bodenmais in Bavaria, in Transylvania, and the United States.

\* In the South of France, and some other countries, semi-fossil ivory and bones are found, coloured by phosphate of iron, which resemble the oriental turquoise in colour and hardness: but when burnt, they exhale a fœtid smell of animal matter, and are said to lose their colour by exposure to damp. This is called by jewellers *turquoise de nouvelle roche*; the other, *turquoise de vieille roche*.

*Anglarite*, of a leek-green colour, contains less phosphoric acid than *vivianite*; it has been observed at Limoges.

*Kakoxene*, a phosphate of iron with alumina and silica, is a mineral of a bright straw-yellow colour, which occurs in radiated tufts of silky fibres in iron ore, in Bohemia.

*Triphylline*, *Triplite*, and *Hureaulite* are phosphates of iron and manganese, which are disseminated in small crystals in the rocks of Limousin.

6. PHOSPHATE OF COPPER. There are two kinds of this mineral; one has been found in Cornwall and at Libethen (in Hungary), in small crystals of an intense green colour, which are rectangular octahedrons; they are generally bright, and sometimes quite black externally, but the powder is a clear bright green.

*Pseudomalachite*, the phosphate of Rheinbreitherch, has the same dark green colour; but it forms radiated masses, and incrustations of slender prismatic crystals, closely pressed together. Both afford water by calcination.

7. PYROMORPHITE (Phosphate of lead). A beautiful mineral which occurs in the lead mines of various countries, though not abundantly. Its colour varies from bright grass-green to yellow, orange, brown, and sometimes a dull violet. It occurs in clusters of hexagonal prisms, occasionally terminated at each end by a low pyramid, or modified as No. 58, p. 120; or as an incrustation resembling moss. The crystals have generally a greasy lustre, but are sometimes very brilliant, and mostly translucent; specific gravity 7.

Pyromorphite undergoes a change by fusion, which is peculiar to it: the melted globule in cooling becomes angular, and assumes a polyhedral form.

Most specimens contain 9 or 10 per cent. of the chloruret of lead; sometimes, arseniate; and those of an orange colour, some chromate of lead. Fine specimens are obtained from the lead mines of Durham, of Leadhills, Brittany, the Hartz and other European localities; besides several places in the United States, particularly the Perkiomen lead mine near Philadelphia.

8. URANITE (Phosphate of Uranium; Uran mica). The lamellar structure of this mineral, somewhat resembling mica, joined to its brilliant yellow or green colour, distinguishes it from all others. When crystallized, it appears in square or octagonal tables, sometimes modified by narrow planes on the edges of the base. The yellow uranite consists of phosphate of uranium and lime, with 15 per cent. of water: in the green uranite (Chalkolite), of which splendid specimens are obtained from some of the tin and copper mines of Cornwall, the lime is replaced by copper: it is found also in Saxony and Bohemia.

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### FAMILY XIII.—ARSENIDES.

Arsenic is found in the metallic state, both alone and forming alloys, which are *arseniurets*; its oxyde, also, producing several *arseniates*; but the greater part of all these species are scarce and unimportant substances.

#### Genus I. ARSENIC.

When freshly broken, arsenic is nearly white, with a bright metallic lustre; but after being exposed for a short time to the air it becomes very dark grey, in consequence of tarnishing. It is brittle, and when struck produces a ringing sound. It is almost entirely volatile by heat, giving off a strong odour of garlic.

Native arsenic is found in many of the localities of nickel and cobalt ores; and in Norway crystallized beryls are sometimes embedded in it.

#### Genus II. ARSENIURETS.

1. SMALTINE (Tin white Cobalt; Arsenical cobalt). Its crystallizations are the same as those of Galena, and do not exhibit the dodecahedral modifications of cobalt glance, from which it is further distinguished by its pale grey colour: the faces of the crystals are generally convex and intersected by irregular cracks; it is also massive, and reticulated.

It consists essentially of arsenic and cobalt, the quantity of the

latter varying from 18 to 26 per cent. A great part of the smalt of commerce is manufactured from this ore, which is obtained abundantly in Saxony and Bohemia; it is met with also in several other parts of Europe, but in less quantity.

2. KUPFERNICKEL (Arsenical Nickel). A metallic substance of a reddish colour and rather brittle, which is found in many of the localities of the cobalt ores. Its solution in nitric acid is green, but becomes violet blue by the addition of ammonia. Specific gravity 7 to 7.6.

From this ore is obtained the nickel used for chemical preparations, and in the different alloys called *German silver* and *nickel silver*; some of these contain 25 per cent. of nickel, combined with zinc and copper. The *white copper* of the Chinese is a similar alloy, containing 31 per cent. of nickel.

3. ARSENICAL SILVER is distinguished from native silver by its brittleness, and the arsenical fumes when heated: it occurs in the Hartz.

4 and 5. ARSENICAL ANTIMONY occurs in the Dauphiné and the Hartz: ARSENICAL BISMUTH, in the silver mines of Schneeberg: both are rare.

### Genus III. OXYDE OF ARSENIC.

WHITE ARSENIC (Arsenious acid; Arsenic bloom). This is the same substance as the arsenic of the shops, and is found either in the form of a white powder, or in small compact masses (very rarely) crystallized in octahedrons and tetrahedrons.

It has been thought to be a result of artificial heat, in consequence of refining operations carried on in the mines; or of some natural conflagration that has occurred in them.

### Genus IV. ARSENIATES.

1. ARSENIATE OF LIME (Pharmacolite). When pure, this substance is white, but it is often of a rose colour, from a mixture of arseniate of cobalt; occurs in delicate acicular crystals aggregated in small parcels, or small hexagonal prisms. It is

distinguished from the preceding substance by not being wholly volatile.

2. ARSENIATE OF COBALT (Erythrine). Of a crimson, or rose colour, approaching to violet; sometimes crystallized in oblique prisms, but oftener in small masses of a botryoidal form, with a fibrous structure. It is found with ores of cobalt, and with arsenical minerals.

3. NICKEL OCHRE. The arseniate of nickel is of a green colour, pulverulent, or in delicate filaments: it often accompanies Kupfernickel.

4. ARSENIATE OF LEAD (Mimetese). It takes the same form as the phosphate of lead, but the prisms are often swelled in the middle, so as to have something of a *barrel shape*: colour, generally pale yellow-brown, and lustre often silky. It is found in Cornwall and some other mining districts.

#### Arseniates of Copper.

There are several species of this ore, which resemble each other in giving off alliaceous fumes when heated, and, if dissolved in nitric acid, depositing copper on any piece of iron dipped into it. Hardness, in general, 3 to 4.

5. COPPER MICA (Erinite) occurs in thin transparent crystals resembling laminæ of mica, which are hexagonal and of a deep emerald-green. It contains 59 per cent. of oxyde of copper, with arsenious acid, and water.

6. LIROCONITE (Lenticular copper ore). In general, it is easily distinguished by its light greenish blue colour, and the form of its crystals, which are rectangular octahedrons, very obtuse, sometimes with the edges truncated. This species contains 35 per cent. of water.

7. OLIVEN ORE (Right prismatic arseniate). The colour of this mineral is yellowish or olive-green of various shades: crystals are sometimes nearly black; they occur in little tufts on quartz, or as a velvety coating.

*Wood copper* is a name given to specimens of this ore, which have a fine fibrous texture and brownish colour: some of these are very soft, and may be reduced to powder by the fingers.



8. TRIHEDRAL OLIVEN ORE (Aphanesite) resembles the preceding species in its general appearance ; but the crystals are derived from an *oblique* prism, and most usually their trihedral points only are visible.

All these species are found in some or other of the Cornish mines : Liroconite appears to be peculiar to them.

*Copper froth* contains about 13 per cent. of carbonate of lime.

*Euchroïte*, of a fine green colour, and *Condurrite*, of a brownish black, are also arseniates of copper.

Arseniates of Iron.

9. CUBE ORE (Pharmacosiderite) occurs in very small cubic crystals of a dark green colour, and usually with bright faces : the cubes often have the alternate angles truncated, like the crystals of boracite (No. 46, p. 73). From the mines of Cornwall, France, and Saxony, where it is found with brown hæmatite and copper ores.

*Skorodite*,\* in minute, bluish, transparent crystals from the same localities ; it contains less water than the preceding species.

## SECOND CLASS.

### LEUCOLYTES.

The elements which are the types of families in this class, are susceptible of forming colourless solutions.

### FAMILY I.—ALUMINIDES.

The earth alumina occurs uncombined, and also as the mineralizing element of spinel, and some few other substances.

1. SAPPHIRE. This beautiful gem, which, next to the diamond, is the hardest substance in nature, is pure alumina. It crystallizes in forms belonging to the rhombohedral series ; generally hexagonal prisms and double pyramids, and presenting few additional planes. The primary rhombohedron, which is very slightly acute, may sometimes be obtained by cleavage ;

\* *Skorodon*, garlic.

but sapphire, being very tenacious as well as hard, often breaks with a conchoidal fracture. Its specific gravity is 3·9 to 4·1.

The most usual colours of the sapphire are blue and bluish grey; when it is of a clear rose or crimson colour, it is called *oriental ruby*; when yellow, *oriental topaz*; if purple, *oriental amethyst*; and if green, *oriental aquamarine* or *chrysolite*, according to the tint; but it is easily distinguished from all the stones whose names it bears, by its great hardness and weight. The term *oriental*, it must be observed, is usually applied in jewellery, to the hardest and most valuable kinds of gems, without regard to their chemical nature.

Some sapphires, when polished with a rounded surface at right angles to the axis of the crystal, exhibit a luminous chatoyant star of six rays, and are called *asterias*; this appearance occurs oftener in the blue and white, than in the other varieties, and is quite independent of their degree of transparency; some *asterias* being perfectly transparent, and others faintly translucent.

*Corundum* is a less pure variety of the same substance, containing a small amount of oxyde of iron and some silica. Crystals of corundum, similar to those of sapphire, are found of a large size; but the faces are often very irregular, and rarely smooth and bright as in most hard crystalline minerals. It is more easily cleavable than the sapphire; and generally of a dark grey colour.

*Emery* is corundum in a granular form, and of a dark iron-grey or brownish colour. Some bluish varieties, translucent and compact, have been called *diamond spar*, or *adamantine spar*.

The finest blue sapphires are brought from Ceylon, where they are found, more or less rounded, in the sand of certain localities with hyacinths: the best oriental rubies come from the Capelan mountains near Syriam, in the kingdom of Ava. Corundum, both crystallized and in irregular masses, is found

No. 60.



embedded in granite in various parts of India and China: beautiful crystals, also, of a clear blue and rose colour, are sometimes obtained from the dolomite rocks of Mount St. Gothard.

Emery is found in many countries, generally in scattered masses which appear to have been brought from a distance and worn away by the action of water: in this condition it occurs in Jersey, the Islands of the Grecian Archipelago, and Eastern Prussia. It is much employed in the form of powder, for polishing the surface of metal and glass, and cutting the softer precious stones, such as the emerald and amethyst.

2. GIBBSITE (Hydrate of alumina). A white or greenish mineral occurring in stalactitic and mammellated forms, of a white or greenish colour: it consists of 64·8 alumina, and 34·7 water, thus bearing the same relation to corundum, as opal to quartz. Found in iron ore in Massachusetts.

*Diaspore* contains less water, and occurs in slender and brilliant greenish prisms, embedded in the limestone of the Ural Mountains. Wavellite was at first confounded with this substance and received the same name, before its composition was known.

#### ALUMINATES.

1. SPINEL (Spinel ruby; Balas ruby). The spinel ruby differs considerably from the red sapphire, or oriental ruby: it crystallizes in octahedrons, which are sometimes modified (figs. 5 and 10), and often maced (No. 19, p. 11). It is rather less hard than the sapphire, but scratches topaz; specific gravity 3·7. Consists principally of alumina combined with magnesia.

The fine red colour for which the ruby is esteemed, is derived from a small quantity of chromic acid; but spinels are often colourless, yellowish, pale green and blue, and dark violet and brown: the light colours are transparent, the dark ones nearly opaque.

Jewellers give the name *spinel* generally to those stones which have a colour approaching to scarlet; they call the paler

ones, *balas ruby*; and those which incline to an orange tint, they denominate *rubicelle*.

The crystals of spinel occur with those of sapphire and hyacinth, in the beds of streams, among sand and pebbles which appear to be the debris of granitic and micaceous rocks, principally in Ceylon; where they are also met with embedded in granular limestone.

The *Balas* rubies were brought formerly from the province of Balachan, in Usbec Tartary, where they were found of great beauty and value: Marco Polo makes mention of them and says, that the rubies of Balachan were monopolized by the Sovereign, who, in order to enhance their price, prohibited the working of the mines.

*Pleonaste* or *Ceylanite*, in small black brilliant octahedral crystals, is abundant in some of the micaceous rocks ejected from Vesuvius: a variety of a brown colour and without lustre is found at Laach, on the Rhine. Pleonaste contains from 16 to 20 per cent. of oxyde of iron.

*Automolite* resembles spinel in hardness and crystallization; but the magnesia is replaced by oxyde of zinc. It has a higher specific gravity, 4.6, and its colour is generally dark iron-grey. At present it is found only in Sweden and in New Jersey.

2. **PLOMBGOMME** (Aluminate of lead). A substance consisting chiefly of alumina, lead, and water, which has the appearance of yellowish gum, but scratches fluorspar. It occurs in some lead mines of Huelgoat, in Brittany.

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## FAMILY II.—MAGNESIDES.

**BRUCITE** (Hydrate of Magnesia). This mineral resembles in its appearance the most beautiful varieties of white pearly talc; but as it consists wholly of magnesia and water it is entirely soluble in the acids, without effervescence: this character distinguishes it also from the transparent lamellar gypsum.

It has been found in serpentine in New Jersey, and Unst, one of the Shetland Isles.

FAMILY III.—STANNIDES.

Tin is not found in the metallic state.

### Oxydes.

**TINSTONE** (Cassiterite). The oxyde of tin is its chief ore, and the one from which all the tin used in the arts and manufactures is obtained.

When pure, it is colourless and transparent : but it is much oftener brown, sometimes black, from the oxyde of iron it generally contains. The crystals are derived from a square prism ; figs. 20, 23, 24, are the most common ; a macle or twin crystal of fig. 20 also occurs frequently, as here represented, and a similar combination of fig. 23. In hardness it is always equal to quartz, scratching glass and felspar ; and when scratched or pulverized, the streak and powder are always white. Its specific gravity is 6·5 to 7, which is nearly as high as that of metallic tin.



Tinstone is sometimes massive and granular; in the latter case, it is much intermixed with quartz, the usual veinstone of tin ore; crystals of tourmaline, apatite, fluorspar, and topaz are also found in tin veins; the latter, particularly in Saxony, and occasionally in Cornwall: chlorite also is abundant in tin veins.

*Stream tin* consists of rolled fragments of tinstone, and grains of various sizes intermixed with bits of rock, sand, and pebbles, in the beds of streams and other low grounds. This ore is collected for smelting; and being separated from the earthy matter with which it is intermixed by washing in a stream of water, the places where this operation is carried on, are called stream-works, and the ore itself stream-tin. In some of these localities, grains of gold are found mixed with the tin.



*Wood tin* is the same substance occurring in pebbles or nodules, with a compact fibrous structure, generally of a light brown colour and variegated with dark and yellowish concentric bands : those which exhibit dark spots or rings on the surface are sometimes called *toad's-eye-tin*.

Tinstone is an ore found in many parts of the globe, but there are few in which it exists in great quantity. The Cornish mines are by far the most productive in Europe, affording probably ten times as much as all the others. They were explored and worked by the ancient inhabitants of Britain, who traded in this ore with the Phoenicians, afterwards with the Greeks established at Marseilles, and still more lately with the Romans, who took much trouble to find out whence their predecessors had obtained tin.

Next to Cornwall, the greatest quantity of tin is obtained from the mines of Malacca and the Island of Banca : and in Europe, principally in Bohemia and Saxony, whence some of the finest crystallized specimens are obtained.

The uses of tin are numerous : the ease with which it may be alloyed with other metals, or spread thinly over them—its brightness, ductility, and the important property of not rusting by exposure to the air, or by the contact of liquids—render it highly advantageous as a coating for various kinds of vessels, particularly those employed in cooking : copper vessels thus coated were sometimes used by the Romans, as we learn from Pliny, though they were by no means common.

Tin is requisite in the preparation of a fine scarlet dye, and some of the crimson and purple colours used in glass-staining.

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#### FAMILY IV.—HYDRARGYRIDES.

1. NATIVE MERCURY (Quicksilver). Globules of this metal are often attached to masses of cinnabar, and it is found occasionally in larger quantity in cavities of the veins. Sometimes it is dispersed through the cinnabar, and oozes from it on being gently heated.

The appearance of metallic mercury is well known; its property of remaining fluid at ordinary temperatures distinguishes it from all other metals, which are rendered liquid only by the application of heat. Mercury, therefore, to become solid, must be exposed to a degree of cold far greater than that which we experience in this climate; at  $39^{\circ}$  below zero of Fahrenheit it becomes solid, and is then malleable.

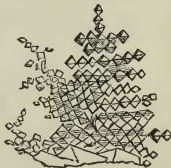
Mercury unites readily with several other metals, for which reason it is used in the extraction of gold, and sometimes of silver, from their ores. The recent discovery of cinnabar in Upper California will therefore be eminently useful in that region; and fluid mercury will probably be found with it, as well as in other parts of Mexico. With tin it forms the amalgam or *silvering* for the backs of mirrors. In the native state it is sometimes found combined with a small quantity of silver.

2. NATIVE AMALGAM (Argentiferous Mercury). In appearance, it exactly resembles silver, crystallizing in some of the same forms (figs. 3 and 9), but with little lustre. It is softer than silver, and much heavier; specific gravity 14. This also is found with cinnabar, but is a rare substance.

#### FAMILY V.—ARGYRIDES.

NATIVE SILVER. Like the silver of commerce, this is a white malleable metal, rather harder than gold, with a specific gravity of 10·3, to 10·5: it is equally liable to become tarnished, and it happens sometimes that in consequence of cavities in the veins, or from the silver lying near the surface of the earth, it is somewhat tarnished in the mine: the streak, however, is always silver-white. Its crystals belong to the cubic series, and are most frequently octahedral, but without any trace of cleavage. The crystals are frequently grouped in

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rows, crossing each other at right angles, not unlike the branches of some kinds of fir-tree. It often occurs in wiry filaments and moss-like tufts, less commonly in leaves or plates, and sometimes in solid masses of great size, both in Europe and America. The silver mines of Kongsberg, in Norway, have produced blocks weighing 500 lb. and upwards: and at Schneeberg, in Saxony, a large and rich vein was discovered in 1478, and a block was cut from it, chiefly of metal, of such size, that Duke Albert of Saxony descended into the mine and made use of it as a dining table: it was afterwards smelted, and produced 44,000 lb. of silver. In the United States, silver is found associated with native copper in the mines of Lake Superior, and often penetrating it; and in Mexico and Peru it is frequently intermixed, in the form of small particles and fine threads, with the chloruret of silver and iron ochre. Quartz and calcspar are the earthy minerals most frequently found with it.

Native silver has been obtained from some of the Cornish mines, but in very small quantity: indeed, there seem to be few countries in which this metal, or some of its ores, is not met with. A good deal was, at one time, raised in Scotland and coined: and there are mines in France which still yield a considerable quantity. In the plain called the Pampa de Navar, filaments of silver are often found adhering to the roots of the grass. The silver ores of South America, however, are said to be in general far less rich in metal than those of Europe; and are more productive, only because they exist there in larger quantity, and are more extensively worked.

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#### FAMILY VI.—PLUMBIDES.

**NATIVE LEAD.** A substance of rare occurrence. It has been observed in small grains and laminæ in some volcanic products, and also, it is said, in specimens of galena from Alston Moor. It may be distinguished by its softness and sectility from the galena, which is hard and brittle.

## OXYDES OF LEAD.

1. **MINIUM** (Red Oxyde of Lead). A red substance, occurring in the form of powder in some veins of galena and calamine. It is the same substance as the red lead used in painting; but for this and other purposes it is prepared artificially.

2. **YELLOW OXYDE OF LEAD** (Native litharge). This lead ore, which is less oxydized than the preceding species, occurs sometimes as a powder, sometimes in solid masses, not unlike yellow jasper; its great weight distinguishes it from all minerals which otherwise resemble it.

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FAMILY VII.—ANTIMONIDES.

**NATIVE ANTIMONY.** A metal of silver-white colour and brilliant lustre, which is found in small masses, with some arsenical and antimonial ores, as in Dauphiné and the Hartz. It may be distinguished from native silver by its octahedral cleavage, though it does not crystallize; and by evaporating before the blowpipe in white fumes.

## ANTIMONURET.

**ANTIMONIAL SILVER** (Discrase). White and rather brittle: distinguished from the preceding by affording a globule of silver by the blowpipe.

## OXYDES OF ANTIMONY.

1. **WHITE ANTIMONY** (White Oxyde of Antimony) occurs in small lamellar masses, with a perfect rectangular cleavage. It is sometimes yellowish white, and has a somewhat pearly lustre: soft and extremely fragile: specific gravity 5.57: fusible in the flame of a candle. It is found in very small quantity with other ores of antimony.

*Earthy white antimony* is the same oxyde combined with water, which occurs as a powder on the grey antimony ore.

2. **RED ANTIMONY ORE** (Kermes). A compound of the oxyde and sulphuret of antimony, which has a dull crimson

colour. It forms tufts of delicate acicular crystals, sometimes radiating, sometimes interlaced, and as fine as hairs. It is scratched by almost all other minerals. It is at present a scarce substance, met with occasionally on the surface of grey antimony ore, and among the ores of arsenic; but which, if found abundantly, would be a profitable mineral.

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#### FAMILY VIII.—ZINCIDES.

The principal ores of zinc have been described in the families *carbonate*, *sulphuret*, &c., to which they belong. It is never found in a metallic state: but we are acquainted with an oxyde which is now wrought as a zinc ore.

**SPARTALITE** (Red Oxyde of Zinc). It occurs in lamellar masses and grains of a fine deep red colour, and brilliant lustre, strongly translucent; or in thin fragments, transparent. Hardness between 4 and 5, scratching red copper and red silver ore. With borax it fuses to a yellow transparent glass.

Spartalite is found embedded in iron ore at Sparta, New Jersey, and at Franklin in the same State.

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#### FAMILY IX.—BISMUTHIDES.

This family contains only native bismuth and the oxyde of bismuth.

**NATIVE BISMUTH.** A metal of a reddish white colour, lamellar, and cleavable parallel to the planes of the octahedron: sometimes it appears in the form of a crystalline arborescence; specific gravity 9.7. When heated by the blowpipe, bismuth evaporates, and is converted into an oxyde which is deposited as a yellow powder on the charcoal.

It is not a very abundant metal; but a quantity sufficient for the few purposes to which it is applied, is obtained from the mines of Saxony and Bohemia, where it is found principally in the veins that afford red silver and cobalt ores. It has been met with in some of the Cornish mines, but in very small quantity.



Bismuth has been sometimes employed in the fabrication of type metal; but one of its principal uses is in making *solder*; being fusible at a lower heat than any other metal, it imparts this property to its alloys. Teaspoons made of a compound of 8 parts of bismuth, 5 of lead, and 3 of tin, will melt on boiling water being poured on them.

#### OXYDE OF BISMUTH.

BISMUTH OCHRE occurs in the form of a yellow powder in the localities of native bismuth.

### THIRD CLASS.

#### CHROÏCOLYTES.

The types of this class are solid and metallic substances, all of which are capable of forming coloured solutions in acids.

### FAMILY I.—TITANIDES.

Metallic titanium is not ascertained to exist in nature; it has been found in iron slags and old blast furnaces, in the form of small cubes of a bright copper colour.

#### OXYDES.

1. **RUTILE** (Titanite; Oxyde of Titanium). Generally of a dark cherry-red; when it contains iron, passing to brown, with a sub-metallic lustre; but the purer varieties are of a bright red, and transparent. Its crystals are right prisms of eight or twelve sides, seldom with perfect terminations; jointed crystals sometimes occur, composed of two or three of these.

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It is brittle, about as hard as felspar; and the specific gravity 4.25, which, together with its distinct lateral cleavage, will distinguish it from red schorl and some other minerals.

Rutile is found embedded in granite and other similar rocks, and particularly in the quartz veins which traverse them; its

slender prisms penetrating the crystals in all directions: specimens of rock crystal enclosing parallel fibres of this ore have, when polished, a beautiful appearance, and have been sold under the designation of *Venus' Hair*.

Fine specimens are obtained from many parts of the Alps, from Spain, Norway, and North America. In Brazil and Ceylon, rolled fragments are found in the sand with the sapphires and zircons.

*Brookite* has the same colour as rutile, but appears to crystallize in oblique rhombic prisms or tables: it has been found in Dauphiné, and in the rock crystal of Snowdon, where it was first observed.

2. **ANATASE** (Octahedrite). This also is an oxyde of titanium. It is found only in small crystals, which are acute square octahedrons, of a dark violet colour, or nearly black; translucent, and extremely brilliant. It is scarcely so hard as rutile. Dauphiné and the Pyrenees afford good specimens of anatase, intermixed with chlorite and adularia.

### TITANATES.

1. **NIGRINE** (Iserine; Menaccanite; Titaniferous iron sand). This is a combination of iron with titanitic acid, which occurs in the form of black grains or sand. In Cornwall it was found in the Valley of Menaccan, whence the name *Menaccanite*, and in this substance the metal titanium was first discovered. It is met with in the beds of streams in many countries, and disseminated in various serpentine rocks, and others of igneous origin, sometimes in minute octahedral crystals.

*Ilmenite*, which occurs in somewhat larger masses in the Urals near Minsk, is thought to be the same substance.

*Crichtonite* is another rare variety, from the Alps.

*Pyrochlore*, containing cerium and uranium, and *Polymignite*, containing yttria and zirconia, combined with the oxyde of titanium, are rare substances, embedded in the zircon syenite of Norway.

2. **SPHENE** (Siliceo-titanate of lime; Spinthere; Ligurite).

The transparent crystals of this mineral are often of a bright yellow-green colour, and so brilliant that they might well pass for some kind of gem: the opaque ones are dark reddish brown, and, at first sight, not unlike zircons: they are derived, however, from a very oblique rhombic prism, often presenting numerous modifications which are difficult to distinguish. The name is from *sphen*, the Greek for a wedge, in reference to their form. Many localities in the Alps afford good specimens: particularly, fissures in the granite and other rocks.

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#### FAMILY II.—TANTALIDES.

The few minerals in which tantalum is combined, are very rare: they have been found very sparingly in the granitic rocks near Fahlun in Sweden; the tantalite also in Connecticut, and baierine in Bavaria.

**TANTALITE** (Columbite). A black substance with scarcely any metallic lustre, about as hard as felspar, which occurs in small masses and imperfect prismatic crystals. The metal *tantalum* was discovered in an American specimen, and at first received the name of Columbium: it was found to consist of 83 per cent. of the oxyde of this metal, with 17 of the oxydes of iron and manganese: it sometimes contains some oxyde of tin.

*Baierine* contains a larger proportion of iron, and crystallizes in rectangular prisms.

*Yttrotantalite*, or *Yttrocolumbite*, is chiefly a tantalate of yttria; of a greenish or brownish black, and when powdered, grey; becoming yellow before the blowpipe, and after some time, white; less hard than the preceding.

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#### FAMILY III.—TUNGSTIDES.

The metal Tungsten or Scheelium (so named from the chemist, Scheele, its discoverer) exists only as an oxyde, either alone or forming tungstates.

**TUNGSTIC OCHRE**, or tungstic acid, is a bright yellow powder

which is found sometimes on the surface of Wolfram, or filling small cavities. Insoluble, and producing with the salt of phosphorus a blue glass; thus differing in chemical characters from any similar mineral.

#### TUNGSTATES.

1. **WOLFRAM** (Tungstate of Iron and Manganese). A dark brown mineral with semi-metallic lustre, affording distinct and brilliant cleavages parallel to a right-rhomboidal prism. It has a good deal of resemblance to bronzite and to uncrystallized blende; but its high specific gravity, 7.3, distinguishes it from both.

It is common in many of the Cornish mines, and other metalliferous districts; but is of no use, except to afford the tungstic acid, which is prepared for laboratories, and of which it contains about 78 per cent.

2. **TUNGSTATE OF LIME** (Scheelite) crystallizes in square octahedrons, both obtuse and acute, often modified by additional planes: translucent, and generally white. Specific gravity 6. It occurs in some tin mines, but rarely in Cornwall; and in Connecticut, with bismuth.

3. **TUNGSTATE OF LEAD** is a scarce mineral, of a greenish colour, which has been found in the tin mines of Bohemia.

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#### FAMILY IV.—MOLYBDIDES.

**MOLYBDIC OCHRE** (Oxyde of Molybdenum) occurs as a yellow powder thinly covering the sulphuret of this metal; melted with the salt of phosphorus, it produces immediately a green glass.

**MOLYBDATE OF LEAD** crystallizes in square octahedrons, or very short prisms of 4 or 6 sides, of a dull yellow colour, and translucent, which contain 64 per cent. of oxyde of lead. Its chief locality is the Bleiberg (lead mountain), in Carinthia, which affords great variety and fine specimens of the ores of lead.

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## FAMILY V.—CHROMIDES.

Chrome is not found in the metallic state: its oxyde is a green ochry substance which is generally intermixed with siliceous minerals; sometimes in felspathic or talcose rocks; or combined with other oxydes.

1. CHROMIC IRON is a black ore, with but little metallic lustre; massive, and sometimes crystallized in octahedrons: occasionally it is attractable by the magnet: specific gravity 4.4, hardness 5.5.

This ore has been for some years sought after, to obtain from it the chromic acid, for the preparation of the beautiful *chrome-yellow* used in painting and dying. It has been found in serpentine in the Shetland Isles, in Styria, the department of Var in France, and other localities; and very abundantly in Maryland and other parts of the United States.

Distinguished from magnetic iron by less lustre, and by affording a bright green glass with borax.

2. CHROMATE OF LEAD (Crocoïse; Red Lead ore). This is the same substance as the chrome-yellow artificially prepared. When crystallized, its colour is of a deep red-orange, and, when powdered, orange-yellow; the crystals, which are semi-transparent, are oblique rhombic prisms, the base nearly square. They are generally small and slender, and occur with galena, and sometimes pyromorphite, at Beresof, in Siberia; it has been found more recently, also, at Congonhas do Campo, in Brazil.

*Vauquelinite* is a chromate of lead, with 10 per cent. of oxyde of copper, which has been found with the above in green acicular crystals.

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FAMILY VI.—URANIDES.

Besides the phosphate which has been described, uranium occurs as an oxyde, alone, or combined with water.

1. PITCHBLENDE (Oxydulated Uranium). This is a black or brownish black substance with semi-metallic lustre, scarcely



so hard as felspar: it is infusible alone, but gives a green colour to the flame. It is found in some veins of silver ore in Saxony and Bohemia, also in Cornwall, but it is a rare mineral.

2. URAN OCHRE occurs as a powder, of a light yellow colour, which becomes orange when gently heated, and gives off water when calcined. The oxyde of uranium has been applied to painting on porcelain, to produce a fine orange colour.

#### FAMILY VII.—MANGANIDES.

The ores of manganese are not found in great abundance, though the metal itself is one of the most widely distributed in nature. As an oxyde or a carbonate, it is combined in many iron ores, and exists in many earthy minerals, particularly *mica*, of which it is often the colouring matter.

The native oxydes, of which there are several species, are extensively employed in some manufacturing processes: particularly in the production of chlorine, so essential in bleaching: and in glass-making, to destroy the green tinge which it would often otherwise have. Melted with borax they produce an amethyst-coloured glass.

#### OXYDES OF MANGANESE.

1. PYROLUSITE (Peroxyde of Manganese). It occurs in groups of small brilliant crystals, like cut steel; or in long prisms, generally of eight sides, which have a good deal of resemblance to those of grey sulphuret of antimony, but darker in colour; sometimes forming botryoidal masses with a fibrous structure; also, compact or granular, with numerous small cavities, which are lined or filled with a blackish powder that soils the fingers strongly, and is the same substance in an earthy form.

The specific gravity of pyrolusite is 4·8 to 5; hardness, rather above calcspar.

2. MANGANITE (Hydrous Oxyde of Manganese; Acerdèse). This ore differs from the preceding in containing 10 per cent. of water united with the oxydized metal.

Its appearance is very similar to that of pyrolusite, but the lustre is less metallic and the colour darker. When crushed, the powder is brown, while that of pyrolusite is black. It is also harder than pyrolusite.

*Wad* is the same substance, of an earthy texture, sometimes appearing compact when broken: it often occurs in singular dendritic and stalactitic forms, with a smooth surface, but no lustre.

If this substance be mixed with linseed oil, and kneaded into a dough, the mass will inflame spontaneously.

All these varieties, as well as the pyrolusite, are obtained in large quantity at Upton Pyne, in Devonshire; also, in Aberdeenshire, the Pyrenees, and many other parts of Europe.

Both species are easily distinguished by the blowpipe, from ores of similar appearance.

3. **PSILOMELANE** (Barytiferous Oxyde of Manganese). Another hydrous oxyde which contains from 4 to 16 per cent. of the earth *baryta*. It does not crystallize, has a bluish-black colour, and when heated with glass of borax produces a violent effervescence.

It occurs with the above-named ores, principally in the neighbourhood of Macon in Burgundy.

*Braunite* and *Hausmannite* are rare species, crystallizing in square octahedrons of a brownish-black colour, and semi-metallic.

*Marceline* is an oxyde containing 15 or more per cent. of silica, which is found abundantly in the valley of St. Marcel in Piedmont, enclosing several interesting substances embedded in it.

Of all these species, the pyrolusite is the most advantageous, being the most highly oxydized, and free from any other substance, except accidental impurities. The oxygen gas employed in chemical experiments may be obtained from it, by exposing it to heat in a retort; and when powdered and mixed with muriatic acid, chlorine is given off, which is perceptible by its strong pungent odour.

## FAMILY VIII.—SIDERIDES.

## Genus I.

1. NATIVE IRON. Metallic iron is found in very small quantity beneath the surface of the earth: it occurs in small laminæ and thin veins among iron ores; and in small particles in some lavas, both ancient and modern.

There are, however, many large masses of metallic iron scattered over the earth's surface, which are known to be of meteoric origin, the period and circumstances of their fall having been recorded, sometimes with great precision. They are perfectly metallic, attractable by the magnet, and malleable; and are all found to contain from 1 to 10 per cent. of nickel, and sometimes a very small quantity of chrome or cobalt.

There are many other metallic masses of whose descent from the atmosphere we have no account, but they are found to consist of a similar alloy; and, judging from this, and the similarity of their insulated situation, it is impossible not to conclude that they have had the same origin.

A mass of iron weighing 71 lb., which fell with a smaller fragment, on the explosion of a meteor, in Croatia, in 1751, is to be seen in the Imperial Cabinet of Vienna; and at the town of Ellbogen in Bohemia, a mass of iron weighing 200 lb. is preserved, which was seen to fall from the air.

The great mass of iron near Jenissek, in Siberia, which contains grains of chrysolite embedded in it, is supposed to weigh 1600 lb.: another, on the banks of the River Plata, is calculated to weigh about 100,000 lb.; and there are many others of all sizes in different countries.

## OXYDES OF IRON.

1. PEROXYDE OF IRON (Specular Iron or Iron Glance; Red Hæmatite; Red Ironstone). The crystallized varieties of this ore have a dark steel-grey colour, and a splendid metallic lustre; and the surface is often tarnished like tempered steel: when scratched or pulverized, however, the powder is dark

cherry-red, and thin fragments, viewed in a strong light, appear of the same colour. The crystals are acute rhombohedrons, generally with complex modifications; some are thin hexagonal tables with oblique edges. The most brilliant specimens come from the Isle of Elba, where mines of this ore have been worked above 2000 years. Some specimens are attractable by the magnet, but this is not a constant character.

*Micaceous iron* is the same substance in thin scales: in this form it is scattered through some quartzose rocks, having the appearance of plumbago: in this situation it occurs in Brazil and Coromandel.

In the British Museum is a specimen of specular iron, in hexagonal plates, in which a topaz is embedded.

*Red Hæmatite* is always opaque, seldom with any metallic lustre, of a blood-red colour, inclining to steel-grey. It occurs in large nodules and stalactitic forms, with a fine radiated structure: the fibres are sometimes above a foot in length.

*Red ironstone* is compact or somewhat granular, and often very pure.

*Red ochre* and *red chalk* (redde) have an earthy and somewhat unctuous texture; they generally contain a good deal of clay.

*Clay ironstone.* An abundant ore, consisting of the red oxyde mixed with earthy substances, chiefly clay and siliceous matters: it is generally dark red or brown, and sometimes very hard. This must not be confounded with the impure *carbonate* of iron which is also called clay ironstone, and will effervesce in warm nitric acid.

The red iron ores are abundant in some parts of England, particularly at Ulverstone, in Lancashire, where an immense vein affords all the varieties, accompanied by calcspar: also in Lanarkshire.

Pieces of hæmatite are much used in the potteries and other manufactories, as burnishers; and a great deal of red chalk is sawn up into crayons.

2. BROWN IRON ORE (Hydrous Oxyde of Iron; Hydrate

of Iron ; Limonite ; Morass Ore ; Yellow Ochre). This ore is of a dark coffee-brown colour, except in the earthy varieties ; but when powdered, is yellow : it is softer and more brittle than the red iron ore, and not so heavy. When pure, it consists of 85·3 of peroxyde of iron and 14·7 of water : but it often contains a little of the oxyde of manganese and silica.

*Brown hæmatite* resembles the red hæmatite in its fibrous structure ; but has a silky lustre, and the colour is sometimes varied by bands of a lighter tint near the surface.

*Brown ironstone* is compact, sometimes intermixed with clay.

*Bog ore* and *morass ore* are of loose, unequal, friable texture, and occur in low swampy grounds. There is not much of this sort in Great Britain, except at the foot of the Cheviot Hills, though in other parts of Europe it is abundant, and in France is extensively smelted.

*Pea iron ore* is the same substance occurring in small globular masses compressed together : in the Jura mountains there are extensive beds of it : these grains, when broken, appear to consist of concentric layers.

All these varieties are much used in the iron works of France and Prussia ; but until lately, those which occur in England have been neglected, in consequence of the abundance of richer ores.

*Yellow ochre*, which is used in various kinds of painting, is sometimes a very pure hydrate of iron ; but the best kind for these purposes contains a good deal of alumina combined with it. There is a large bed of it near Oxford, which is of a very good quality.

*Umber*, another pigment, contains a large proportion of the hydrous oxyde of manganese.

## Genus II. FERRATES.

1. MAGNETIC IRON ORE (Loadstone ; Oxydulous Iron). This ore has a dark iron-grey colour and metallic lustre, and its hardness and specific gravity are nearly the same as of specular iron ore : massive varieties of these two ores resemble



each other considerably; but they may be distinguished by pulverizing them: the powder of the specular iron is red; that of the magnetic iron, black.

It is always strongly attracted by the magnet, a circumstance which sometimes occurs with the specular ore; but those specimens which exhibit *polarity* are themselves natural magnets or loadstones.

Magnetic iron is scarce in this country, being found only in small crystals, octahedral or dodecahedral (figs. 5, 9, 10), disseminated in serpentine and in some schistose rocks: but in Norway and Sweden it forms immense beds many yards in thickness, and even constitutes mountains, as at Taberg and Dannemora; and at Gellivara in Lapland. It occurs in many other countries, particularly the United States, but not in such extensive masses.

2. **FRANKLINITE** is a combination of oxyde of iron with the oxydes of manganese and zinc, which is found at Franklin, in New Jersey. It crystallizes in octahedrons, and has very much the appearance of magnetic iron, but somewhat less metallic, and the streak is reddish brown.

#### COBALTIDES.

3. **BLACK OXYDE OF COBALT** (Cobalt Ochre). A black earthy substance which occurs in several places, both in Europe and America, usually on the surface of other ores of cobalt, and of arsenic, but seldom pure. The ore from Missouri, of which a good deal is now exported to England, for the purpose of being converted into smalt, contains 40 per cent. of the oxydes of cobalt, with oxydes of nickel, manganese, iron, and copper.

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#### FAMILY IX.—CUPRIDES.

**NATIVE COPPER.** Like most of the native metals, it crystallizes in the octahedral system; but perfect crystals are seldom met with. It occurs sometimes in very large masses, but most frequently, in branching and leaf-like forms, scattered

among the veinstone, or penetrating it: and the surface of these ramifications is often thinly coated with green carbonate of copper, or tarnished of a brownish colour.

In general it is very nearly pure copper, and has the colour, hardness, and malleability of the refined metal, as we are accustomed to see it: sometimes it contains a minute proportion of silver.

Siberia and Cornwall have for ages afforded abundance of native copper, and some of the finest cabinet specimens; but Brazil and the southern shore of Lake Superior have produced by far the largest masses of metal. A block weighing 3704 lbs. was taken from the last-mentioned spot and conveyed to Washington: but many larger ones are said to have been obtained from the same locality. In some parts of this district, the copper is penetrated by threads of pure silver, and grains of the same metal are scattered through it; a circumstance which has never been observed elsewhere.

Its softness and ready solubility in every kind of acid, and in ammonia, distinguish copper from the few metallic minerals which at all resemble it.

Copper is one of the metals that has been known and worked from the earliest period: alloyed with tin its hardness is much increased; and this alloy formed the various kinds of bronze of which armour, weapons, knives, and other tools were manufactured by the former inhabitants of both the old and the new continent. Axes and knives from the tombs of the ancient Peruvians and Mexicans, chisels found in the quarries of Egypt, and Roman and Gaulish swords of great antiquity, have been analysed, and found to contain from 75 to 96 per cent. of copper alloyed with tin.

#### OXYDES.

RUBY COPPER (Red Oxyde of Copper; Zigueline). This substance is of a fine crimson colour, sometimes almost black, with a vitreous lustre, varying from semi-transparent to nearly opaque. It crystallizes in octahedrons and dodecahedrons,

sometimes presenting numerous modifications (figs. 4, 5, 9, 10, are the most common): it is brittle, and about as hard as fluorspar, with a specific gravity of 5·6. Detached crystals of a bright colour are very much like spinel rubies; but the difference of their hardness is a sufficient distinction. It is often intermixed with native copper, but seldom with the other ores of this metal.

At Chessy, large and perfect pseudomorphous crystals of malachite are found, having the forms of ruby copper.

*Tile ore* is a variety which is intermixed with oxyde of iron and other impurities, and forms thin flattish masses something like dark coloured tiles.

*Black oxyde of copper*, which is more oxydated than the preceding species, occurs in the form of a fine black powder, or in small masses of an earthy texture, with some other copper ores. Both this and ruby copper are easily reduced on charcoal to metallic copper.

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#### FAMILY X.—AURIDES.

Gold is found only in the native or metallic state; for, though it is alloyed with silver and with tellurium, it is never mineralized by sulphur, oxygen, chlorine, &c., which, in combining with other metals, destroy their metallic character.

1. **NATIVE GOLD** is often nearly pure; but it is almost constantly alloyed with some proportion of silver, which varies from a very small fraction to 72 per cent. When the quantity of silver is but small, it does not differ in appearance from the gold of commerce: it has the same colour, hardness, and malleability, but is less heavy, the specific gravity ranging from 12·6 to 14·7; this variation depends partly on the amount of silver which it contains: the specific gravity of gold when purified is 19·25.

Gold crystallizes in cubes and octahedrons, and other forms belonging to the same series. Some of the gold sand of South America consists chiefly of brilliant crystallized grains; but well-formed crystals of even moderate size are extremely

scarce: it is more commonly disseminated in small irregular lumps or grains, in veins of quartz or calcspar, accompanying other ores: for it does not, like copper pyrites and cinnabar, fill the veins in which it occurs; nor even constitute, like native silver, the principal part of their metalliferous contents; but is scattered through them in minute particles; or spread out here and there into thin leaves; or forms, in their cavities, crystallized tufts.

In Hungary and in some parts of Mexico, gold occurs with the sulphurets of silver: in the Sierra Coçaes of Brazil, beds of granular quartz and micaceous specular iron include a great quantity of native gold in the form of spangles.

Gold was discovered some years since in lead veins in Merionethshire, in sufficient quantity to render the working of it tolerably profitable: it is there sprinkled in fine particles over quartz, or mixed with iron pyrites and decomposing blende. In the Hartz it is found chiefly among decomposing iron pyrites.

Gold, however, is far more abundant in the sand of rivers, and in alluvial tracts, than in any other situations. Most of the gold of South America, and which for many years was the source of the greater part of the gold circulating and manufactured in Europe, is obtained from *washings* in alluvial\* grounds. At Choco, along with the gold, platinum, hyacinths, and rutile occur; and often the trunks of petrified trees: in other localities, diamonds and gold are found together.

In California, where the late discovery of gold has excited such extraordinary interest, both from the extent of country over which it is scattered, and the unusual size of the *pepites* (as they are called) in which it occurs, the soil is alluvial, and diamonds are said to have been met with in several spots. A great quantity exists there in small grains and spangles; the

\* *Alluvial* is a term used to designate the deposits of loose gravel, sand, and mud, which in many regions are spread over all other strata, chiefly in low grounds, and appear as if carried thither by a stream or flood. The word is derived from *alluvio*, an inundation.

large *pepites* are either of solid metal, or quartz intermixed with gold, and in general strongly coloured by hydrous oxyde of iron. The gold mines of the Urals are situated in alluvial soil, and it is observed that the richest spots are generally those which are the most ferruginous. These mines are said to have been, for some years past, the most productive in the world.\*

The native gold of Africa is in the form of dust intermixed sometimes with larger grains. That country, together with Spain, furnished a great part of the gold possessed by the ancients: the mines of Gallicia, according to Diodorus Siculus, were worked by the Phœnicians, and afterwards by the Romans.

Macedonia, Thrace, and the Isle of Thasos, near that coast, also afforded them gold.

The river Pactolus, celebrated for its golden sands, was said to have been a chief source of the wealth of Cræsus, but they have long ceased to be productive.

Borneo, Sumatra, and many other islands of the Indian Archipelago, as well as Cochin China and Siam, possess productive gold mines.

In the time of Queen Elizabeth, extensive gold-washings were carried on in the mining district of Leadhills, Scotland: and in the course of a few summers, the quantity collected there, amounted to £100,000. In Wicklow, also, gold was for a short time obtained from a small alluvial tract: and particles of gold occur sometimes in the Cornish stream works.

2. **ELECTRUM** is a name applied to a native alloy of 64 parts of gold with 36 of silver. Pliny says that "all gold contains more or less silver combined with it, and that when the latter amounts to a *fifth* part of the weight it is called *electrum*." When the proportion of silver is large, the alloy has a brassy colour. It is met with generally in *veins*, in Siberia, Hungary, and Transylvania, but not often in sand or grains.

\* The whole of the Russian mines yielded, in 1842, 42,000 lbs. troy, of which half was from Siberia.



Gold is insoluble in every acid except *aqua regia* (a mixture of nitric and hydrochloric acids), and neither becomes oxydized nor tarnished by exposure to the air. Its extreme malleability, in addition to these properties, renders it a most economical as well as beautiful ornamental material, notwithstanding its high value. It amalgamates readily with mercury, for which reason this metal is used in some places with great advantage for separating gold from the *gangue* or earthy matter with which it is intermixed.

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#### FAMILY XI.—PLATINIDES.

NATIVE PLATINUM (*Platina*). This metal, which is the heaviest known substance, is found only in the metallic state, generally alloyed with a small quantity of *palladium*, *iridium*, *osmium*, *rhodium*, or *iron*: sometimes it is combined with two or three of these metals. It has a pale lead-grey colour, and is found in grains, which are generally very small, rarely as large as a pea. In this state its specific gravity is about 17, but when purified it is 19·5, or rather higher than that of gold.\*

Platinum is a most indestructible substance; being infusible at a heat which liquifies gold, and unaffected by every acid except the *aqua regia*; it is, therefore, of great value as a material for crucibles and other chemical apparatus. It is also extremely malleable, and so ductile that it has been drawn into wire less than the ten-thousandth of an inch in diameter.

Platinum was discovered about a hundred years since, in the sands of Barbaçoa and Choto, in South America: it was afterwards found in the gold district of Brazil, whence a considerable quantity was obtained annually. But in 1824 it was discovered on the western side of the Ural Mountains; and the mines of that district have for several years produced a far greater quantity than all the American localities, and the most

\* Platinum, which has been rendered more dense by hammering, has a sp. gr. from 21 to 23.

remarkable specimens in point of size and weight : one of these, in the Demidoff Cabinet, weighs 21 lbs. troy; another,  $11\frac{1}{2}$ .

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#### FAMILY XII.—PALLADIDES.

**PALLADIUM.** Among the grains of Platinum are generally intermixed very small ones of a lighter colour, and sometimes a radiated texture, which have a specific gravity of 11·3 or 11·8. These are Palladium: the grains have usually a flat shape, and are soluble in heated nitric acid.

Palladium has been advantageously used in small slips, to inlay parts of astronomical instruments, where fine graduated lines are cut, being nearly as white as silver, and not liable to tarnish or become oxydated. In the Mint at Paris, there is a highly polished cup of this metal.

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#### FAMILY XIII.—OSMIDES.

**IRIDOSMINE (Native Iridium).** An alloy of Osmium with Iridium, which occurs in small grains in some of the localities of Platinum. Their specific gravity is above 19, and they are insoluble alone, even in aqua regia.

The metal iridium received its name from *iris*, the rainbow, because its different solutions exhibit all the colours of the rainbow.

## ON ROCKS OR MINERAL AGGREGATES.

BY JAMES D. DANA, A.M.

*General Nature of Rocks.*—The rocks of the globe are mineral, and consist either of a single mineral in a massive state, or of intimate combinations of different minerals. Limestone, when pure, is a single mineral; it is the species calcite or carbonate of lime. Common *granite* is a compound or aggregate of three minerals—quartz, feldspar, and mica. *Sandstones* may consist of grains of quartz alone, like the sands of many sea-coasts, being such a rock as these sands would make if agglutinated; it is common to find along with the quartz, grains of feldspar, and sometimes mica. *Clay Slates* consist of quartz and feldspar or clay, with sometimes mica, all so finely comminuted that often the grains cannot be observed. *Conglomerates* or *puddingstones*, may be aggregates of pebbles of any kind: of granite pebbles, of quartz pebbles, of limestone pebbles, or of mixture of different kinds, cemented together by some cementing material, such as silica, oxyde of iron, or carbonate of lime.

*Texture or structure of Rocks.*—Rocks differ also in texture. In some, as granite, or syenite, the texture is crystalline: that is, the grains are more or less angular, and show faces of cleavage; the aggregation was the result of a cotemporaneous crystallization of the several ingredients. Common statuary or white building marble consists of angular grains, and is crystalline in the same manner. But a pudding-stone is evidently not a result of crystallization; it consists only of adhering pebbles of other rocks with a cementing material which is often not apparent. Sandstones also are an agglutination of grains of sand,—just such rocks as would be made from ordinary sand by compacting it together; and clay slates are often just what

would result from solidifying a bed of clay. There are therefore *crystalline* and *uncrystalline* rocks. It should be remembered, however, that in each kind of rock the grains themselves are crystalline, as all solid matter becomes solid by crystallization. But the *former* kind is a crystalline aggregation of grains, the *latter* a mechanical aggregation.

In crystalline rocks it is not always possible to distinguish the grains, as they may be so minute, or the rock so compact, that they are not visible. Much of the crystalline rock called basalt is thus compact.

*Positions, or modes of occurrence, of Rocks.*—A great part of the rocks of the earth's surface constitutes extensive beds or layers, lying one above the other, and varying in thickness from a fraction of an inch to many scores of yards. There are compact limestones, beds of sandstone, and shales or clay slates, in many and very various alternations. In some regions, certain of these rocks, or certain parts of the series, may extend over large areas or underlie a whole country, while others are wholly wanting or present only in thin beds. The irregularities in their geographical arrangement and in the order of superposition are very numerous, and it is one object of geology to discover order amid the apparent want of system. Thus in Pennsylvania, over a considerable part of the state, there are sandstones, shales, and limestones, connected with beds of coal. In New York there are other sandstones, shales, and limestones, without coal; and the geologist ascertains at once, by his investigation, that no coal can be found in New York. These rocks contain each its own peculiar organic remains, and these are one source of the confident decision of the geologist. The stratified rocks bear evidence in every part—in their regular layers, their worn sand or pebbles, and their fossils—that they are the result of gradual accumulations beneath water, marine or fresh, or on the shores of seas, lakes, or rivers.

Besides the *stratified rocks* alluded to, there are others which, like the ejections from a volcano, or an igneous vent, form beds, or break through other strata and fill fissures often many

miles in length. The rock filling such fissures, is called a dike. Such are the *trap dikes* of New England and elsewhere; they are fissures filled by trap. Porphyry dikes, and many of the veins in rocks, are of the same kind. Similar rocks may also occur as extensive layers; for the lavas of a single volcanic eruption are sometimes continuous for forty miles. They may appear underlying a wide region of country, like granite.

The stratified rocks, or such as consist of material in regular layers, are of two kinds. The worn grains of which they are made are sometimes distinct, and the remains of shells farther indicate that they are the result of gradual accumulation. But others, or even certain parts of beds that elsewhere contain these indications, have a crystalline texture. A limestone bed may be compact in one part, and granular or crystalline, like statuary marble, in another. Here is an effect of heat on a portion of the bed; heat, which has acted since the rock was deposited. Other rocks, such as mica slate, gneiss, and probably some granites, have thus been crystallized.

In these few general remarks on the structure of the globe, we have distinguished the following general facts:

1. The great variety of alternations of sandstone, conglomerates, clay shale, and limestones.

2. The existence of igneous rocks in beds and intersecting dikes or veins.

3. The mechanical structure of sandstone, conglomerate, and shales.

4. The crystalline character of igneous rocks.

5. The crystalline character of many stratified or sedimentary rocks, arising from the action of heat upon the beds of rock themselves, after they were first formed.

We follow this comprehensive survey of the arrangement and general nature of rocks, with descriptions of the more prominent varieties and their applications in the arts.\*

\* One of the most important uses of stone is for architectural purposes. The character of the material depends not only upon its durability, but



## GRANITE.—SYENITE.

*Granite* consists of the three minerals, quartz, feldspar, and mica. It has a crystalline granular structure, and usually a greyish-white, grey, or flesh-red colour, the shade varying with the colour of the constituent minerals. When it contains hornblende in place of mica, it is called *syenite*; hornblende resembles mica in these rocks, but the laminæ separate much less easily and are brittle.

Granite is said to be *micaceous*, *feldspathic*, or *quartzose*, according as the *mica*, *feldspar*, or *quartz* predominates.

It is called *porphyritic* granite, when the feldspar is in large crystals, and appears over a worn surface like thickly scattered white blotches, often rectangular in shape.

*Graphic* granite has an appearance of small oriental cha-

also its contraction or expansion from changes of temperature. This latter cause occasions fractures or the opening of seams, and produces in cold climates serious injuries to structures. The following table, by Mr. A. J. Adie, gives the rate of expansion in length for different materials, for a change of temperature of 180° F.—*Proc. Roy. Soc. Edinb.*, i. 95, 1835.

|   |                      |
|---|----------------------|
| Granite,                                  | •0008968—•0007894    |
| Sicilian white marble,                    | •00110411            |
| Carrara marble,                           | •0006539             |
| Black marble, from Galway, Ireland,       | •00044519            |
| Sandstone, (Craigleith quarry, Scotland,) | •0011743             |
| Slate, Penryhn quarry, Wales,             | •0010376             |
| Greenstone,                               | •0008089             |
| Best Brick,                               | •0005502             |
| Fire brick,                               | •0004928             |
| Cast iron,                                | •00114676—•001102166 |
| Rod of wedgewood ware,                    | •00045294            |

The experiments of W. H. C. Bartlett, Lieut. U. S. Engineers, led to the following results.—*Amer. J. Sci.*, xxii. 136, 1832.

|                  | For 1° F.  | For 180° F. |
|------------------|------------|-------------|
| Granite,         | •000004825 | •00086904   |
| Marble,          | •000005668 | •00102024   |
| Sandstone,       | •000009532 | •00171596   |
| Hammered copper, | •000009440 | •00169920   |

racters over the surface, owing to the angular arrangement of the quartz in the feldspar, or of the feldspar in the quartz.

When the mica of the granite is wanting, it is then a granular mixture of feldspar and quartz, called *granulite* or *leptynite*.

When the feldspar is replaced by albite, it is called *albite* granite. The albite is usually white, but otherwise resembles feldspar.

Granite is the usual rock for veins of tin ore. It contains also workable veins of pyritous, vitreous, and grey copper ore, of galena or lead ore, of zinc blende, of specular and magnetic iron ore, besides ores of antimony, cobalt, nickel, uranium, arsenic, titanium, bismuth, tungsten, and silver, with rarely a trace of mercury. The rare cerium and yttria minerals are found in granite, and most frequently in albitic granite. It also contains emerald, topaz, corundum, zircon, fluor spar, garnet, tourmaline, pyroxene, hornblende, epidote, and many other species.

Granite is one of the most valuable materials for building. The rock selected for this purpose should be fine and even in texture, as the coarser varieties are less durable; it should especially be pure from pyrites or any ore of iron, which on exposure to the weather will rust and destroy, as well as deface, the stone. The only certain evidence of durability must be learned from examining the rock in its native beds; for some handsome granites which have every appearance of durability, decompose rapidly from some cause not fully understood. The more feldspathic are less enduring than the quartzose, and the syenitic (or hornblendic) variety, more durable than proper granite itself. The rock, after removal from the quarry, hardens somewhat, and is less easily worked than when first quarried out.

Massachusetts is properly the granite state of the union. New Hampshire and Maine also afford a good material. The Quincy quarries in Massachusetts, south of Boston, have for many years been celebrated. Besides this locality, there are

others in the eastern part of this state, between cape Ann and Salem, in Gloucester, at Fall River, in Troy, in Danvers; also south, between Quincy and Rhode Island, where it is wrought in many places, as well as in Rhode Island, even to Providence. The so-called Chelmsford granite comes from Westford and Tyngsborough, beyond Lowell; and an excellent variety is obtained at Pelham, a short distance north in New Hampshire. Masses 60 feet in length are obtained at several of the quarries. They are worked into columns for buildings, many fine examples of which are common in Boston, New York, and other cities.

Good granite is also quarried in Waterford, Greenwich, and elsewhere, in Connecticut.

The granite is detached in blocks by drilling a series of holes, one every few inches, to a depth of three inches, and then driving in wedges of iron between steel cheeks. In this manner masses of any size are split out. There is a choice of direction, as the granite has certain directions of easiest fracture. Masses are often got out in long narrow strips, a foot wide, for fence posts. The granite in a rough state brings 12 to 15 cents. the superficial foot; ordinary hewn granite 20 to 40 cents. the foot; worked into columns, 50 cents. to 1 dollar the foot, according to the size.

Granite is also used for paving, in small rectangular blocks neatly fitted together, as in London and in some parts of New York and other cities. The feldspathic granite is of great value in the manufacture of porcelain, for which purpose it is therefore extensively employed.

Granite was much used by the ancients, especially the Egyptians, where are obelisks that have stood the weather for 3000 years.

#### GNEISS.

Gneiss has the same constitution as granite, but the mica is more in layers, and the rock has therefore a stratified appearance. It generally breaks out in slabs a few inches to a foot thick. It is hence much used both as a building material and

for flagging walks. The quarries in the vicinity of Haddam, Conn., on the Connecticut river, are very extensively opened, and a large amount of stone is annually taken out and exported to the Atlantic cities, even as far as New Orleans. There are also quarries at Lebanon and other places, in Connecticut; at Wilbraham, Millbury, Monson, and many other places, in Massachusetts.

#### MICA SLATE.

Mica slate has the constitution of gneiss, but is thin, slaty, and breaks with a glistening or shining surface, owing to the large proportion of mica, upon which its foliated structure depends. Grey or silvery grey is a common colour.

The thin even slabs of the more compact varieties of mica slate are much used for flagging, and for door and hearth stones; also for lining furnaces. The finer arenaceous varieties make good *scythe stones*.

It is quarried extensively of fine quality, in large even slabs, at Bolton in Connecticut; also in the range passing through Goshen and Chesterfield, Mass. It is worked into whetstones in Enfield, Norwich, and Bellingham, Mass., and extensively at Woonsocket Hill, Smithfield, R. I. The south part of Chester, Vt., affords a slate like that of Bolton. Mica slate is used at Salisbury, Conn., for the inner wall of the iron furnace.

*Hornblende slate* resembles mica slate, but has not as glistening a lustre, and seldom breaks into as thin slabs. It is more tough than mica slate, and is an excellent material for flagging.

#### TALCOSE SLATE.—TALCOSE ROCK.

*Talcose slate* resembles mica slate, but has a more greasy feel, owing to its containing talc instead of mica. It is usually light grey or dark greyish-brown. It breaks into thin slabs, but is generally rather brittle, yet it often makes good fire-stones.

A talcose slate in Stockbridge, Vt., is worked for scythe stones and hones, and is of excellent quality for this purpose.

*Talcose rock* is a kind of quartzose granite, containing more or less talc, and often quite compact. It is usually very much intersected by veins of white quartz. Much of it contains chlorite (an olive-green mineral) in place of talc, here and there disseminated: and there is a *chlorite slate*, of a dark green colour, similar in general characters to talcose slate. Talcose rock passes into a flinty quartz rock.

The talcose rocks are to a great extent the gold rocks of the world, especially the quartzose veins, as mentioned under Gold. It contains the topaz of Brazil, and also euclase, and many other minerals.

#### STEATITE, OR SOAPSTONE.

*Steatite* is a soft stone, easily cut by the knife and greasy in its feel. Its colour is usually greyish-green; but when smoothed and varnished it becomes dark olive-green. It occurs in beds, associated generally with talcose slate.

Owing to the facility with which soapstone is worked, and its refractory nature, it is cut into slabs for fire-stones and other purposes, and the powder, finely prepared, is employed for diminishing friction, and for mixing with blacklead in the manufacture of crucibles. It is also used, as observed by Dr. C. T. Jackson, for the sizing rollers in cotton factories, one of which is  $4\frac{1}{2}$  feet long and 5 to 6 inches in diameter. The most valuable quarries in Massachusetts are at Middlefield, Windsor, Blandford, Andover, and Chester; in Vermont, at Windham and Grafton; in New Hampshire, at Francestown, and Oxford; in Orange county, North Carolina. The Frances-town soapstone sells at Boston at from 36 to 42 dollars the ton, or from 3 to  $3\frac{1}{2}$  dollars the cubic foot.

Steatite often contains disseminated crystals of magnesian carbonate of lime (dolomite,) and brown spar; also crystals of pyrites and actinolite.

*Potstone* is a compact steatite. Rensselaerite is another compact variety, found in Jefferson and St. Lawrence counties, N. Y., and used for inkstands.



## SERPENTINE.

This dark green rock is usually associated with talcose rocks, and often also with granular limestones. It has been already described, and its uses alluded to. It often contains disseminated a foliated green variety of hornblende called *diallage*. A compound rock, consisting of *diallage* and feldspar, has been called *diallage rock* or *euphotide*.

## TRAP.—BASALT.

*Trap* is a dark greenish or brownish-black rock, heavy and tough. Specific gravity 2·8—3·2. It has sometimes a granular crystalline structure, and at other times it is very compact without apparent grains. It is an intimate mixture of feldspar and hornblende. It is often called *greenstone*; and when consisting of albite and hornblende, it is called *diorite*.

*Amygdaloid* (from the Latin *amygdalum*, an almond,) is a trap containing small almond-shaped cavities, which are filled with some mineral; usually a zeolite, quartz, or chlorite.

*Porphyritic trap* is a trap containing, like porphyritic granite, disseminated crystals of feldspar.

*Basalt* is a rock resembling trap, but consisting of augite and feldspar. It varies in colour from greyish to black. In the lighter coloured, which are sometimes denominated *grey-stone*, feldspar predominates; and in the darker, iron or a ferruginous augite. It often contains chrysolite (or olivine) in small grains of a bottle-glass appearance. Magnetic or titaniferous iron are also frequently present in the rock. When feldspar crystals are coarsely disseminated, it is called *porphyritic basalt*; and when containing minerals in small nodules, it is *amygdaloidal basalt*; when consisting of labradorite and augite, it is called *dolerite*.

*Wacke* or *toadstone* is an earthy basalt, or a sedimentary rock of trap or basaltic material.

Both trap and basalt occur in columnar forms, as at the Giant's Causeway and other similar places.

Trap and basalt are excellent materials for macadamizing

roads, on account of their toughness. Trap is also used for buildings. It breaks into irregular angular blocks, and is employed in this condition. For a Gothic building it is well fitted, on account of an appearance of age which it has.

## PORPHYRY.—CLINKSTONE.—TRACHYTE.

*Porphyry* consists mainly of compact feldspar, with disseminated crystals of feldspar. Red or brownish-red and green, are common colours ; but grey and black are met with. The feldspar crystals are from a very small size to half or three quarters of an inch in length, and have a much lighter shade of colour than the base, or are quite white. It breaks with a smooth surface and conchoidal fracture. The specific gravity and other characters of the rock are the same nearly as for the mineral feldspar ; the hardness is usually a little higher than in that mineral.

Porphyry receives a fine polish, and has been used for columns, vases, mortars, and other purposes. Green porphyry is the *oriental verd antique* of the ancients, and was held in high esteem. The red porphyry of Egypt is also a beautiful rock. It has a clear brownish-red colour, and is sprinkled with small spots of white feldspar.

*Clinkstone* or *Phonolite* is a greyish-blue rock, consisting, like porphyry, mainly of feldspar. It passes into grey basalt, and is distinguished by its less specific gravity. It rings like iron when struck with a hammer, and hence its name.

*Trachyte* is another feldspathic rock, distinguished by breaking with a rough surface, and showing less compactness than clinkstone. It sometimes contains crystals of hornblende, mica, or some glassy feldspar mineral. It occurs in volcanic regions.

## LAVA.—OBSIDIAN.—PUMICE.

The term *lava* is applied to any rock material which has flowed in igneous fusion from a volcano. Basalt is one kind of lava ; and when containing cellules, it is called *basaltic lava*. Trachyte is also a lava. There are thus both feldspathic and

basaltic lavas. The feldspathic are light-coloured, and of low specific gravity (not exceeding 2·8); the basaltic vary from greyish-blue to black, and are above 2·8 in specific gravity. The general term *basaltic* sometimes includes *doleritic* lava, which is closely allied. Chrysolite is often present in basaltic lavas; and they are not unfrequently porphyritic, or contain disseminated crystals of feldspar.

The light cellular ejections of a volcano are called *scoria* or *pumice*.

Pumice is feldspathic in constitution; it is very porous, and the fine pores lying in one direction make the rock appear to be fibrous. It is so light as to float on water. It is much used for polishing wood, ivory, marble, metal, glass, &c., and also parchment and skins. The principal localities are the islands of Lipari, Ponza, Ischia, and Vulcano, in the Mediterranean, between Sicily and Naples. Both scoria and pumice are properly the scum of a volcano.

*Volcanic ashes* are the light cinders or minute particles of rock, ejected from a volcano in the course of an eruption.

*Obsidian* is a volcanic glass. It resembles ordinary glass. Black and smoky tints are the common colours. In Mexico, it was formerly used both for mirrors, knives, and razors. *Pitchstone* is less perfectly glassy in its character, and has a pitch-like lustre; otherwise it resembles obsidian. *Pearlstone* has a greyish colour and pearly luster. *Spherulite* is a kind of pearlstone, occurring in small globules in massive pearlstone. *Marekanite* is a pearl-grey translucent obsidian from Marekan in Kamschatka.

#### ARGILLACEOUS SHALE, OR CLAY SLATE.—ARGILLITE.

*Slate* is an argillaceous rock, breaking into thin laminæ; *shale*, a similar rock, with the same structure usually less perfect and often more brittle; *schist* includes the same varieties of rock, but is extended also to those of a much coarser laminated structure. The ordinary clay slate has the same constitution as mica slate; but the material is so fine that the in-

gredients cannot be distinguished. The two pass into one another insensibly. The colours are very various, and always dull or but slightly glistening.

*Roofing slate* is a fine grained argillaceous variety, commonly of a dark dull blue or bluish-black colour, or somewhat purplish. To be a good material for roofing, it should split easily into even slates, and admit of being pierced for nails without fracturing. Moreover, it should not be absorbent of water, either by the surface or edges, which may be tested by weighing after immersion for a while in water. It should also be pure from pyrites and everything that can undergo decomposition on exposure.

Roofing slates occur in England, in Cornwall, Devon, Cumberland, and Westmoreland.

In the United States, a good material is obtained in Maine, at Barnard, Piscataquies, Kennebec, Bingham, and elsewhere; also in Massachusetts, in Worcester county, in Boylston, Lancaster, Harvard, Shirley, and Peperell; in Vermont, at Guilford, Brattleborough, Fairhaven, and Dummerston; in Hoosic, New York; on Bush creek, and near Unionville, Maryland; at the Cove of Wachitta, Arkansas. At Rutland, Vt., is a manufactory of slate pencils from a greenish slate.

These slate rocks are also used for gravestones; and we cannot go through New England cemeteries without frequent regret, that a material which is sure to fall to pieces in a few years should have been selected for such records.

*Drawing slate* is a finer and more compact variety, of bluish and purplish shades of colour. The best slates come from Spain, Italy, and France. A good quality is quarried in Maine and Vermont.

*Novaculite*, *hone-slate*, or *whet-stone*, is a fine grained slate, containing considerable quartz, though the grains of this mineral are not perceptible. It occurs of light and dark shades of colour, and compact texture. It is found in North Carolina, seven miles west of Chapel Hill, and elsewhere; in Lincoln and Oglethorpe counties, Georgia; on Bush creek,

and near Unionville, Maryland; and at the Cove of Wachitta, Arkansas.

*Argillite* is a general term given to argillaceous or clay slate rocks. Many shales or argillites crumble easily, and are unfit for any purpose in the arts, except to furnish a clayey soil.

*Alum shale* is any slaty rock which contains decomposing pyrites, and thus will afford alum or sulphate of alumina on lixiviation.

*Bituminous shale* is a dark-coloured slaty rock containing some bitumen, and giving off a bituminous odour.

*Plumbaginous schist* is a clay slate containing plumbago or graphite, and leaving traces like black lead.

The *Pipestone* of the North American Indians, was in part a red claystone or compacted clay from the Coteau de Prairies. It has been named *catlinite*. A similar material, now accumulating, occurs on the north shore of Lake Superior, at Nepigon bay. Another variety of pipestone is a dark greyish compact argillite; it is used by the Indians of the northwest coast of America.

*Agalmatolite* is a soft mineral, impressible by the nail, and waxy in lustre when polished, presenting greyish and greenish colours and other shades. Gr. = 2·8—2·9. It has a greasy feel. It consists of silica 55·0, alumina 30·0, potash 7·0, water 3 to 5 per cent., with a trace of oxyde of iron. It is carved into images, and is hence called *figure-stone*.

#### QUARTZ ROCK.

*Quartz rock* is a compact rock consisting of quartz, and often appearing granular. Its colours are light grey, reddish, or dull bluish; also sometimes brown.

When the granular quartz contains a little mica, it often breaks in slabs like gneiss or mica slate. The *itacolumite* of Brazil, with which gold and topaz are associated, is a micaceous granular quartz rock of this kind.

*Flexible sandstone* is an allied rock of finer texture. Gran-



ular quartz graduates into the proper sandstones, which are treated of for convenience on a following page. The two rocks are properly parts of one series.

Granular quartz is one of the most refractory of rocks. It is consequently used extensively for hearthstones, for the lining of furnaces, and for lime kilns. At Stafford, Conn., a loose grained micaceous quartz rock is highly valued for furnaces; it sells at the quarry for about £3 8s. per ton.\*

Granular quartz is also used for flagging, and a fine quarry is opened in Washington, near Pittsfield, Mass.; it also occurs of good quality at Tyringham and Lee, Mass. In the shape of cobble stones, it is a common paving material.

A highly important use of this rock is in the manufacture of glass and sandpaper, and for sawing marble. In many places it occurs crumbled to a fine sand, and is highly convenient for these purposes. In Cheshire, Berkshire county, Mass., and in Lanesboro', Mass., it occurs of superior quality, and in great abundance. It is also in demand for the manufacture of glass and pottery. In Unity, N. H., a granular quartz is ground for sandpaper and for polishing-powder; the latter is a good material for many purposes.

A fine variety of granular quartz is a material much valued for whet-stones.

#### BUHRSTONE.

*Buhrstone* is a quartz rock containing cellules. It is as hard and firm as quartz crystal, and owes its peculiar value to this quality and the cellules, which give it a very rough surface. In the best stones for wheat or corn the cavities about equal in space the solid part. The finest quality comes from France, in the basin of Paris, and some adjoining districts.

The stones are cut into wedge-shaped parallelopipeds called panes, which are bound together by iron hoops into large mill-stones. The Paris buhrstone is from the tertiary formation, and is therefore of much more recent origin than the quartz rock above described.

\* Rep. on Connecticut, by C. U. Shepard, p. 78.

Buhrstone of good quality is abundant in Ohio, and others of the western states. It is associated there with proper sandstones.

The quartz rock of Washington, near Pittsfield, Mass., is in some parts cellular, and makes good millstones.

A buhrstone occurs in Georgia, about 40 miles from the sea, near the Carolina line; also in Arkansas, near the Cove of Wachitta.

SANDSTONES.—GRIT ROCKS.—CONGLOMERATES.

*Sandstones* consist of small grains, aggregated into a compact rock. They have a harsh feel, and every dull shade of colour from white, through yellow, red, and brown, to black. Many sandstones are very compact and hard, while others break or rub to pieces in the fingers. They usually consist of siliceous sand; but grains of feldspar are often present. In many compact sandstones there is much clay, and the rock is then an argillaceous sandstone.

Sandstones are of all geological ages, from the lower Silurian to the most recent period. The older rocks are in general the most firm and compact. The “old red” sandstone is a sandstone below the coal in age; while the so-called “new red” is more recent than the coal. But these terms, beyond this particular point, are of somewhat indefinite application. The sandstone of the Connecticut valley is called the new red sandstone.

*Grit rock.* When the sandstone is very hard and harsh, and contains occasional siliceous pebbles, it is called a grit rock, or millstone grit.

*Conglomerates.* Conglomerates consist mostly of pebbles compacted together. They are called *pudding stone* when the pebbles are rounded, and *breccia* when they are angular. They may consist of pebbles of any kinds, as of granite, quartz, limestone, &c., and they are named accordingly *granitic*, *quartzose*, *calcareous*, *conglomerates*.

The use of sandstone as a building material is well known. For this purpose it should be free, like granite, from pyrites or

iron sand, as these rust and disfigure the structure. It should be firm in texture, and not liable to peel off on exposure. Some sandstones, especially certain argillaceous varieties, which appear well in the quarry, when exposed for a season where they will be left to dry, gradually fall to pieces. The same rock answers well for structures beneath water, that is worth nothing for buildings. Other sandstones which are so soft as to be easily cut from their bed without blasting, harden on exposure, (owing to the hardening of silica in the contained moisture,) and are quite durable. These are qualities which must be tested before the stone is used. Moreover, it should be considered that in frosty climates a weak absorbent stone is liable to be destroyed in a comparatively short time, while in a climate like that of Peru even sunburnt bricks will last for centuries.

Dr. Ure observes, that "such was the care of the ancients to provide strong and durable materials for their public edifices, that but for the desolating hands of modern barbarians, in peace and in war, most of the temples and other public monuments of Greece and Rome would have remained perfect at the present day, uninjured by the elements during 2000 years. The contrast in this respect of the works of modern architects, especially in Great Britain, [much more true of the United States,] is very humiliating to those who boast so loudly of social advancement; for there is scarcely a public building of recent date which will be in existence a thousand years hence." Many splendid structures are monuments (not endless) of folly in this respect. He observes, also, that the stone intended for a durable edifice ought to be tested as to its durability by immersion in a saturated solution of sulphate of soda, and exposure to the air for some days: the crystallization within the stone will cause the same disintegration that would result in time from frost.

The dark red sandstone (*freestone*) of New Jersey and Connecticut, when of fine gritty texture and compact, is generally an excellent building material. Trinity Church in New York

is built of the stone from Belville, New Jersey. At Chatham, on the Connecticut, is a large quarry, which supplies great quantities of stone to the cities of the coast; and there are numerous others in the Connecticut valley, both in Connecticut and Massachusetts. A variety in North Haven, at the east end of Mount Carmel, has been spoken of as excellent for ornamental architecture. That of Longmeadow and Wilbraham, in Massachusetts, is a very fine and beautiful variety and is much used. A *freestone* occurs also at the mouth of Seneca creek, Maryland, convenient for transportation by the Chesapeake and Ohio canal; white and coloured sandstones occur also at Sugarloaf Mountain, Maryland.

The sandstone of the Capitol at Washington is from the Potomac; it is a poor material.

Sandstones that split into thin layers form excellent *flagging stones*, and are in common use.

Hard, gritty sandstones and the grit rocks are used for the *hearths of furnaces*, on account of their resistance to heat. They are also much used for *millstones*, and when of firm texture make a good substitute for the buhrstone.

The true *buhrstone* has been described as a cellular siliceous rock, without an apparent granular texture. The buhrstone of Ohio approaches this character; it is in part a true sandstone containing fossils in some places, and overlying the coal. Much of it contains lime; and it is possible that the removal of the lime by solution, since its deposition, may have occasioned its cellular character. It has an open cellular structure where quarried for millstones. It occurs in Ohio, in the county of Muskingum, and the counties south and west of south, on the Raccoon river and elsewhere. The manufacture commenced in this region in 1807; and in Richland, Elk, and Clinton, and in Hopewell, the manufacture is now carried on extensively. Stones 4 feet in diameter bring \$150.

The "green sand" of the cretaceous formation contains grains of silicate of iron and potash, to which it owes its greenish tint. It occurs abundantly in New Jersey as a soft

rock, and is much used for improving lands; a value it owes mostly to the alkali it contains.

Pudding stones and breccias are fitted, in general, only for the coarser uses of stone, as for foundations, butments of bridges. Occasionally, when of limestone, they make handsome marbles, as the "Potomac breccia marble" on the Monocacy, which forms the columns in the Hall of Representatives of Washington.

*Porphyry conglomerates*, *basaltic conglomerates*, *pumiceous conglomerates*, consist respectively of pebbles or fragments of porphyry, basalt, pumice.

*Tufa* is a sandrock consisting of volcanic material, either cinders or the comminuted lavas. Pozzuolana is a kind of tufa found in the vicinity of Rome, Italy. It consists of silica 34·5, alumina 15, lime 8·8, magnesia 4·7, potash 1·4, soda 4·1, oxydes of iron and titanium 12, water 9·2. *Peperino* is a coarse sandrock, made up of volcanic cinders or fine fragments of scoria, partially agglutinated.

#### LIMESTONES.

Limestones consist essentially of carbonate of lime, and belong to the species calcite, or otherwise of the carbonates of lime and magnesia. They are distinguished by being easily scratched with a knife, and by effervescing with an acid. They are either *compact* or *granular* in texture: the compact break with a smooth surface, often conchoidal; the granular have a crystalline granular surface, and the fine varieties resemble loaf sugar.

*Granular limestone.* The finest and purest white crystalline limestones are used for statuary and the best carving, and are called *statuary marble*. A variety less fine in texture is employed as a building material. Its colours are white, and clouded of various shades. It often contains scales of mica disseminated, and occasionally other impurities, from which the cloudings arise.

The finest statuary marble comes from the Italian quarry at



Carrara ; from the Island of Paros, whence the name Parian ; from Athens, Greece ; from Ornofrio, Corsica, of a quality equal to that of Carrara. The Medicean Venus and most of the fine Grecian statues are made of the Parian marble. These quarries, and also those of the Islands of Scio, Samos, and Lesbos, afforded marble for the ancient temples of Greece and Rome. The Parthenon at Athens was constructed of marble from Pentelicus.

Statuary marble has been obtained in the United States, but not of a quality equal to the foreign. Fine building material is abundant along the Western part of Vermont, and south through Massachusetts to Western Connecticut and Eastern New York. In Berkshire county, Mass., marble is quarried annually to the value of \$200,000 ; the principal quarries are at Sheffield, West Stockbridge, New Ashford, New Marlborough, Great Barrington, and Lanesborough. The columns of the Girard College are from Sheffield, where blocks 50 feet long are sometimes blasted out ; the material of the City Hall, New York, came from West Stockbridge ; that of the Capitol at Albany. from Lanesboro'. At Stoneham is a fine statuary marble ; but it is difficult to obtain large blocks. The variety from Great Barrington is a handsome clouded marble. Some of the West Stockbridge marble is flexible in thin pieces when first taken out. There are Vermont localities at Dorset, Rutland, Brandon, and Pittsford. In New York extensive quarries are opened not far from New York, at Sing Sing ; also at Patterson, Putnam county ; at Dover in Dutchess county, N.Y. ; in Connecticut there are marble quarries at New Prestou ; in Maine at Thomaston ; in Rhode Island at Smithfield, a fine statuary ; in Maryland, a few miles east of Hagerstown ; in Pennsylvania, a fine clouded variety, 20 miles from Philadelphia. A fine *dun-coloured* marble is obtained at New Ashford and Sheffield, Mass., and at Pittsford, Vt.

The granular limestone when coarse usually crumbles easily, and is not a good material for building. But the finer varieties are not exceeded in durability by any other architectural rock,

not even by granite. The impurities are sometimes so abundant as to render it useless. For statuary, it is essential that it should be uniform in tint and without seams or fissures; the liability of finding cloudings within the large blocks would altogether discourage their use for statuary.

The common minerals in this rock are tremolite, asbestos, scapolite, chondrodite, pyroxene, apatite, besides sphene, spinel, graphite, idocrase, mica.

*Verde antique marble*—*verde antico*—is a clouded green marble, consisting of a mixture of serpentine and limestone, as already described under Serpentine. It occurs at Milford, near Newhaven, Connecticut, of fine quality; and also in Essex county, N.Y., at Moria, and near Port Henry on Lake Champlain. A marble of this kind occurs at Genoa and in Tuscany, and is much valued for its beauty. A variety is called *polzivera di Genoa* and *vert d'Egypte*.

The *Cipolin* marbles of Italy are white, or nearly so, with shadings or zones of green talc. The *bardiglio* is a grey variety from Corsica.

*Compact limestone* usually breaks out easily into thick slabs, and is a convenient and durable stone for building and all kinds of stone work. It is not possessed of much beauty in the rough state. When polished it constitutes a variety of marbles, according to the colour; the shades are very numerous, from white, cream, and yellow shades, through grey, dove-coloured, slate blue, or brown, to black.

The *Nero-antico* marble of the Italians is an ancient deep black marble; the *paragone* is a modern one, of a fine black colour, from Bergamo; and *panno di morte* is another black marble with a few white fossil shells.

The *rosso-antico* is deep blood-red, sprinkled with minute white dots. The *giallo-antico*, or yellow antique marble, is deep yellow with black or yellow rings. A beautiful marble from Sienna, *brocatello de Siena*, has a yellow colour, with large irregular spots and veins of bluish-red or purplish. The *mandelato* of the Italians is a light red marble, with yellowish-

white spots ; it is found at Luggezzana. At Verona, there is a *red marble*, inclining to yellow, and another with large white spots in a reddish and greenish paste.

The *black marble* used in the United States comes mostly from Shoreham, Vt., and other places in that state near Lake Champlain. The *Bristol marble* of England is a black marble containing a few white shells, and the *Kilkenny* is another similar. There are several quarries at Isle La Motte. It is quarried also near Plattsburgh and Glenn's Falls, N.Y.

The *portor* is a Genoese marble very highly esteemed. It is deep black, with elegant veinings of yellow. The most beautiful comes from Porto-Venese, and under Louis XIV. a great deal of it was worked up for the decoration of Versailles.

Grey and dove-coloured compact marbles are common through New York and the states West.

The *bird's-eye* marble of Western New York is a compact limestone, with crystalline points scattered through it.

*Ruin marble* is a yellowish marble, with brownish shadings or lines arranged so as to represent castles, towers, or cities in ruins. These markings proceed from infiltrated iron. It is an indurated calcareous marl.

*Oolitic marble* has usually a greyish tint, and is speckled with rounded dots, looking much like the roe of a fish.

*Shell marble* contains scattered fossils, and may be of different colours. It is abundant through the United States. *Crinoidal* or *encrinital marble* differs only in the fossils being mostly remains of encrinites, resembling thin disks. Large quarries are opened in Onondaga and Madison counties, N.Y., and the polished slabs are much used. *Madreporic marble* consists largely of corals, and the surface consists of delicate stars : it is the *pietra stellaria* of the Italians. It is common in some of the states on the Ohio. *Fire marble*, or *lumachelle*, is a dark brown shell marble, having brilliant *fire* or *chatoyant reflections* from within.

*Breccia marbles* and *pudding stone marbles* are the polished calcareous breccia or pudding stone.

Stalagmites and stalactites are frequently polished, and the variety of banded shades is often highly beautiful. The *Gibraltar stone*, so well known, is of this kind. It comes from a cavern in the Gibraltar rock, where it was deposited from dripping water. It is made into inkstands, letter-holders, and various small articles.

Wood is often petrified by carbonate of lime, and occasionally whole trunks are changed to stone. The specimens show well the grain of the wood, and some are quite handsome when polished.

Marble is sawn by means of a thin iron plate and sand, either by hand or machinery. In polishing, the slabs are first worn down by the sharpest sand, either by rubbing two slabs together or by means of a plate of iron. Finer sand is afterwards used, and then a still finer. Next emery is applied of increasing fineness by means of a plate of lead; and finally the last polish is given with tin-putty, rubbed on with coarse linen cloths or baggings, wedged tight into an iron planing tool. More or less water is used throughout the process.

*Quicklime.* Limestone when burnt produces quicklime, owing to the expulsion of the carbonic acid by the heat. The purest limestone affords the purest lime (what is called *fat lime*). But some impurities are no detriment to it for making mortar, unless they are in excess. *Hydraulic lime*, which is so called because it will set under water, is made from limestone containing some clay, silica, and often magnesia. The French varieties contain 2 or 3 per cent. of magnesia, and 10 to 20 of silica and alumina or clay. The varieties in the United States contain 20 to 40 per cent. of magnesia, and 12 to 30 per cent. of silica and alumina. A variety worked extensively at Rondout, N.Y., afforded Prof. Beck carbonic acid 34·20, lime 25·50, magnesia 12·35, silica 15·37, alumina 9·13, peroxyde of iron 2·25. Oxyde of iron is rather prejudicial than otherwise.

In making mortar, the lime is mixed with water and siliceous sand. The final strength of the mortar depends principally

on the formation of a compound between water, the silica (or sand), and the lime; of course, therefore, the finer the sand, the more thorough the combination. In hydraulic lime, there are silica and alumina present in a thoroughly disseminated and finely divided state, which is favourable for the combination alluded to; and to this fact appears to be mainly owing its hydraulic character. Much less sand is added in making mortar from this lime than from that of ordinary limestone.

*Pozzuolana* forms an hydraulic cement when mixed with a little lime and water. Similar cements may be made with tufa, pumice stone, and slate clay, by varying the proportions of lime; these materials consist essentially of silica and alumina or magnesia with alkalies, and often some lime, and therefore produce the same result as with hydraulic limestone.

In the *burning of lime*, the most common mode is to erect a square or circular furnace of stone, with a door for managing the fire below. An arched cavity for the fire is first made of large pieces of limestone, and then the furnace is filled with the stone placed loosely so as to admit of the passage of the flame throughout: the carbonic acid is expelled by the heat, and when the fires are out, the lime now in the state of quicklime, or in other words, pure lime, is taken out. Great economy of fuel is secured by means of what is called a *perpetual kiln*. The cavity within is best made nearly of the shape of an egg with the narrow end uppermost. The inner walls are of quartz rock, mica slate, or some refractory stone or fire brick, and between the inner and outer there is a layer of cinders or ashes, as in the iron furnace. Below are three or more openings for furnaces which lead into the main cavity, a few feet from the bottom; and alternate with these are other openings at a lower level for withdrawing the lime. The lime is taken out below and the stone thrown in above, and this may be kept up without intermission as long as the kiln lasts. Beneath the furnaces there are also ash pits. Such a kiln is most convenient for being filled and emptied when situated on a side hill.



The localities of limestone in the United States are too common to need enumeration. Hydraulic limestone is also abundant.

Quicklime is much used for improving lands ; also for clarifying the juice of the sugar cane and beet root ; for purifying coal gas ; for clearing hides of their hair in tanneries, and for various other purposes.

## SAND.—CLAY.

The loose or soft material of the surface of the earth consists of sand, clay, gravel, or stones, and what we call, in general terms, soil, or earth. These materials are either in layers or irregular beds. Most clay beds, and many of gravel, when cut through vertically, show indications of horizontal layers, a result of deposition, or distribution, by water.

In geological language, these stratified deposits are often classed with rocks, as they graduate into true rocks, and differ only in the amount of cementing material.

The ordinary constituents of earth are quartz, feldspar or clay, oxyde of iron, and lime ; but these vary with the source from whence they are derived. When the rock that has afforded the soil is granite, mica slate, or the allied rocks, mica is usually present, as well as feldspar and quartz : so a quartzose rock will furnish siliceous gravel ; a magnesian, will give magnesia to the soil ; calcareous, lime ; trap, the ingredients of decomposed feldspar or hornblende. The material will be coarse or gravelly, or fine earthy, according to the nature of the rock, or the condition under which it is worn down, or its subsequent distribution by flowing waters. Besides the prominent constituents mentioned, there are small proportions of phosphates, nitrates, chlorides, &c., together with the results of vegetable decomposition ; and these comparatively rare ingredients are of great importance to growing vegetation. The pebbles of a soil are commonly siliceous, as this kind resists wear most effectually.

*Sand* is usually pulverized quartz, often with some feldspar. *Clay* is a plastic earth, consisting mainly of alumina one third

part, and silica (quartz) two thirds. It owes its plasticity to the alumina, and ceases to be called clay when the proportion of silica is too great for plasticity. It is afforded by the decomposition of feldspar and all argillaceous rocks. Oxyde of iron, carbonate of lime, and magnesia are often present in clays.

*Sand for glass manufacture* should be pure silica, free from a taint of iron. This purity is apparent in the clearness of the grains, under a lens, or their white colour. That of Cheshire and Lanesboro', in Massachusetts, is a beautiful material.

In the *manufacture of glass*, the object is to form a transparent fusible compound, and not an opaque infusible one, as in pottery. This result is secured by heating together to fusion, silica (quartz sand or flint powder) and the alkali potash or soda. The ingredients combine and produce a silicate of potash or soda—in other words, glass.

Besides these ingredients, lime or oxyde of lead are added for glass of different kinds. A small proportion of lime increases the density, hardness, and lustre of glass, producing a specific gravity between 2·5 and 2·6; while with lead a still denser material is formed—called *crystal* or *flint* glass—whose specific gravity is from 3 to 3·6.

From 7 to 20 parts of lime are added for 100 of silica, and 25 to 50 of calcined sulphate or carbonate of soda; common salt (chloride of sodium) may also be employed. A good colourless glass has been found by analysis to consist of silica 76·0, potash 13·6, and lime 10·4 parts, in a hundred. For coarse bottle-glass, wood-ashes and coarse sea-weed soda, called *kelp*, or else pearlashes, are used along with siliceous sand and broken glass. For a hard glass, the proportion of alkali is small.

The best English crystal glass analyzed by Berthier, afforded 59 parts of silica, 9 of potash, 28 of oxyde of lead, and 1·4 of oxyde of manganese. Crown glass contains, in general, less alkali than crystal glass, and is superior in hardness. The alkali, moreover, in England, is soda instead of potash. *Plate*

*glass* also contains soda, and this soda (the carbonate) is prepared with great care. The proportions are 7 parts of sand, 1 of quicklime,  $2\frac{1}{3}$  of dry carbonate of soda, besides cullet or broken plate.

The materials are first well pounded and sifted, and mixed into a fine paste; they are then heated together in pots made of a pure refractory clay, until fusion has taken place and the material has settled. The glass is afterwards worked by blowing, or moulded, into the various forms it has in market; and it is finally *annealed*—or in other words, is very slowly cooled—to render it tough. A little oxyde of manganese is usually employed to correct the green colour which glass is apt to derive from any oxyde of iron present. But if the manganese is in excess, it gives a violet tinge to it.

The following chemical distribution of glasses has been proposed:

*Soluble glass.* A simple silicate of potash or soda, or of both of these alkalies.

*Bohemian or crown glass.* Silicate of potash and lime.

*Common window and mirror glass.* Silicate of soda and lime; sometimes also of potash.

*Bottle glass.* Silicate of soda, lime, alumina, and iron.

*Ordinary crystal glass.* Silicate of potash and lead.

*Flint glass.* Silicate of potash and lead; more lead than in the preceding.

*Strass.* Silicate of potash and lead—still more lead.

*Enamel.* Silicate and stannate, or antimonate of potash or soda and lead.

Glass was manufactured by the Phœnicians and the later Egyptians. According to Pliny and Strabo, the glass works of Sidon and Alexandria, whence emanated beautiful articles, were famous in their times. The Romans employed glass to some extent in their windows, and remains of this glass are found in Herculaneum. Window glass manufacture was first commenced in England in 1557.

*Sand for casting* is a fine siliceous sand, containing a little

clay to make it adhere somewhat and retain the forms into which it may be moulded. It must be quite free from lime.

*Tripoli* is a fine grained earthy deposit, having a dry, harsh feel, and a white or greyish colour. It contains 80 per cent. of silica, mostly derived from the casts of animalcules. It is valuable as a polishing material.

*Marl*. Marl is a clay containing carbonate of lime. The material is valuable as manure. The term is also improperly applied to any clayey earth used in fertilizing land. The green sand in New Jersey is sometimes called marl.

*Fuller's earth* is a white, greyish, or greenish-white earth, having a soapy feel, which was formerly used for removing oil or grease from woollen cloth. It falls to pieces in water, and forms a paste which is not plastic. A variety consists of silica 44.0, alumina 23.1, lime 4.1, magnesia 2.0, protoxyde of iron, 2.0. Gr. = 2.45.

*Lithomarge* is a compact clay of a fine smooth texture, and very sectile. Its colours are white, greyish, bluish-white, reddish-white, or ochre-yellow, with a shining streak. Gr. = 2.4—2.5. The *tuesite* of Thomson, a white lithomarge from the banks of the Tweed, is said to make good slate pencils.

*Clay for bricks* is the most ordinary kind; it should have slight plasticity when moistened, and a fine even character without pebbles. It ordinarily contains some hydrated oxyde of iron, which when heated turns red by the escape of the water in its composition, which reduces it to the red oxyde of iron, and gives the usual red colour to the brick. It also frequently contains lime; but much lime is injurious, as it renders the brick fusible. A clay is extensively employed at Milwaukie, in Michigan, which contains no iron, and produces a very handsome cream-coloured brick. About 9,000,000 of this brick were made at that place in 1847.

In *making bricks*, the clay is first well worked by the treading of cattle or by machinery: after this, it is moulded in moulds of the requisite size ( $9\frac{5}{8}$  inches, by  $4\frac{3}{4}$  and  $2\frac{3}{4}$ ,) and then taken out and laid on the ground. A good workman

will make by hand 5000 in a day, and the best 10,000. After drying till stiff enough to bear handling, the bricks are trimmed off with a knife when requiring it, and piled up in long walls for farther drying. They are then made into a kiln by piling them in an open manner (so that the flame and heated draft may have passage among them), and leaving places beneath for the fires. The heat is continued forty-eight hours or more.

The best brick are pressed in moulds. They have a smooth, hard surface. Near Baltimore, Md., bricks are thus made by a machine, worked by a single horse, which will mould 30,000 bricks in twelve hours; the bricks are dry enough when first taken from the mould for immediate burning.

Burnt bricks were not used in England before the eleventh century, when they were employed in the construction of the abbey of St. Alban's. But they date historically as far back as the city of Babylon. Unburnt bricks have also been used in all ages. Those of Egyptian and Babylonish times were made of worked clay mixed with chopped straw, to prevent it from falling to pieces. The *adobies* of Peru are large sun-baked bricks or blocks of clay, and in that dry climate they are very durable.

*Clay for Fire-bricks* should contain no lime, magnesia, or iron, as its value depends on its being very refractory. There is a large manufactory in the United States, at Baltimore, from the tertiary clays of eastern Maryland. In England a slate clay from the coal series is employed.

*Potter's clay* and *pipe clay* are pure plastic clays, free from iron, and consequently burning white. The clay of Milwaukie, from which the cream-coloured bricks are made, is much used also for pottery.

In the *manufacture of coarse pottery*, the clay is worked with water and tempered; and then the required form of a pot or pan is given on a wheel. The ware is dried under cover for a while, and next receives the glaze in a cream-like state. The glaze for the most common ware consists of very finely pul-



verized galena, mixed with clay and water. The ware after drying again is next placed in the kiln, which is very gradually heated; the heat causes the baking of the clay, and drives off the sulphur of the galena, thus producing an oxyde of lead, which forms a kind of glass (or glaze) with the alumina. For a better stone ware, common salt is used, and it is put on after the baking has begun.

For the finer earthenware, a mixture of red and white lead, feldspar, silica, and flint-glass, is used for a glaze, the proportions differing according to the ware. The clay for this ware is mixed with flint powder (ground flints or sand), to render it less liable to contract or break, and it is worked with great care, and through various processes to prepare it for moulding. The ware is usually baked to a biscuit, before the glazing is put on, as in the manufacture of porcelain.

*Kaolin* or *porcelain clay* is derived from the decomposition of feldspar. The foreign kaolin occurs in Saxony; in France at St. Yrieux-la-Perche, near Limoges; in Cornwall, England; also in China and Japan. The kaolin used at the Philadelphia porcelain works comes mostly from the neighbourhood of Wilmington, Delaware.

The name kaolin is a corruption of the Chinese *Kauling*, meaning *high-ridge*, the name of a hill near Jauchau Fu, where this material is obtained.

In the *manufacture of porcelain*, the kaolin, and also the other ingredients, are first ground up separately to an impalpable powder. The kaolin is mixed with a certain proportion of feldspar, flint, and lime. The whole are worked up together in water, by mallets and spades, and well kneaded by the hands and sometimes the feet of the workmen. The plastic material is then laid aside in masses of the size of a man's head, and kept damp till required; the *dough*, as it is called, is now ready for the potter's lathe, (or other means,) by which it is moulded into the various forms of china ware. After moulding, they are slowly and thoroughly dried, and then taken to the kiln, for a preliminary baking. They come out in a state

of *biscuit*, and are ready for painting and glazing. The colours are metallic oxydes, which are put on either from a wet copper-plate impression on bibulous paper, or by means of a brush. The former is used for flat surfaces; the paper is rubbed on carefully to transfer the impression to the porcelain, and is then wet and washed off. It is then carefully heated to evaporate any oil or grease employed in the printing. The glaze is made of a quartzose feldspar; it is ground to a very fine powder and worked into a paste with water, and a little vinegar. The articles are dipped for an instant into this milky fluid, and as they absorb the water they come out with a delicate layer of feldspar in a dry state. They are touched with a brush wherever not well covered. They are then ready to be finally baked in the kiln, for which purpose each vessel is placed in a separate baked clay case or receptacle, called a *sagger*. In this process the material undergoes a softening, amounting almost to a partial fusion, and thus receives the translucency which distinguishes porcelain from earthen or stone ware.

The blue colour of common china is produced by means of oxyde of cobalt; carmine, purple, and violet, by means of chloride of gold; red of all shades, by oxyde of iron; yellow, by oxyde of lead, or white oxyde of antimony and sand; green, by oxyde of copper or carbonate of lead; brown, by oxyde of iron, manganese, or copper. A steel lustre is produced from chloride of platinum.

The best Sèvres ware is made from 63 to 70 parts of kaolin, 15 to 22 of feldspar, nearly 10 of flint, and 5 or 6 of chalk. In China the kaolin is mixed with a quartzose feldspar rock, consisting mainly of quartz, called *peh-tun-tsz*.

*Soapstone* is sometimes used in this manufacture; and as it substitutes magnesia for a part of the potash, it makes a harder ware; but it is also more brittle.



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